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ABSTRACT

This study investigated alternative instructional delivery modes in two different short courses for professional engineers and scientists. Two math-oriented courses were taught to 130 participants. Each course was taught twice, once using the blackboard exclusively and once using extensive view graph projections (20 to 40 transparencies per 90-minute lecture). Each course was offered once on the east coast and once on the west coast. Participants were given pretests of cognitive background and demographic identification. Cognitive and affective posttests were given at the end of a 5-day course and at five weeks and four months following the course. Results of the study with four test classes revealed that blackboard and view graph presentation modes did not produce statistically significant differences in achievement of learning objectives in mathematics-oriented short courses. Student satisfaction was also similar for the two teaching modes. (Author/CS)

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EVALUATION OF SHORT COURSE METHOD OF INSTRUCTION FOR PRACTICING PROFESSIONALS IN ENGINEERING

September 25, 1978–March 31, 1980

Continuing Education in Engineering and Mathematics
University Extension
University of California, Los Angeles
in Cooperation with the
National Science Foundation

July 1980

SE 033 399

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Continuing Education in Engineering and Mathematics

6266 Boelter Hall, UCLA
Los Angeles, California 90024

July 31, 1980

Dr. Gene d'Amour
National Science Foundation, Directorate for Science Education
Division of Science Education Development and Research
Washington, D.C. 20550

Dear Dr. d'Amour:

I am pleased to submit herewith the final report of the subject project, for which the original grant period was April 1, 1979 to March 31, 1980.

You may recall that, while the grant is entitled, "Evaluation of Short Course Method of Instruction for Practicing Professionals in Engineering," the specific objective of the study was to determine whether one of two methods of delivery -- blackboard or view graph -- would yield a clear superiority as a preferred mode of instruction in mathematics-oriented short courses. Our study was conducted on approximately 130 participants in two short courses, "Digital Filters" and "Kalman Filtering," each given twice (once on the east coast at University of Maryland and once at UCLA) utilizing the two different instructional methods.

As the accompanying abstract and report reveals, both courses yielded no significant advantage to either method as regards achievement of cognitive learning objectives. However, there was preference demonstrated by the course participants for the view graph method, because of greater visibility and ease of taking notes.

The experience of engaging in this study has been a rewarding one. I am pleased to report that our results will be the subject of a paper I have been invited to give at the Midwinter Conference of ASEE next January/February in Orlando, Florida.

I look forward to further opportunities to engage in continuing education research and demonstration projects sponsored by the National Science Foundation.

Sincerely,

A. C. Ingersoll

A. C. Ingersoll, P.E.
Principal Investigator

ACI:jb

Enclosure

Grant Number: NSF/SED 78-21979

RE: Evaluation of Short Course Method of Instruction for Practicing Professionals in Engineering

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I. Summary and Conclusions

The objective of the study reported herein was to investigate whether a statistically significant difference in adult learning occurred as a result of using two markedly different instructional delivery modes, viz. blackboard and view graph, in two different offerings each of two math-oriented short courses taught to 130 professional engineers and scientists in 1979. Course participants were given pretests of cognitive background as well as demographic identification. Cognitive and affective posttests were given at the end of the 5-day short course and at five weeks and four months following the course.

As stated in the study proposal, a "statistically significant result" would be where both courses (and their instructors) yielded the same outcome, either (i) the blackboard method is superior to the view graph, or (ii) vice versa, or (iii) it is not possible to discern a statistically significant difference between these instructional modes. Any of these results would be a positive outcome of the study and would justify the project. The investigators were also prepared to see an inconclusive result, where one course and instructor might yield one of the above outcomes while the other yielded a different one, an unfortunate but not uncommon issue of research in any field.

The four test classes of the study yielded the following "positive result": blackboard and view graph presentation modes appear not to reveal a statistically significant difference in achieving learning objectives for mathematics-oriented short courses. Student satisfaction was also similar for the two teaching modes. There appears to be some tendency to favor the view graph because of greater visibility and ease of taking notes. The extent of this difference was obscured, however, by the nature of the lecture rooms and materials used in the study.

Based on the foregoing one might conclude that the extra expense of preparing transparencies might be justified on the basis of students' expressed preference if the course is to be given several times. For a single offering (on a minimum budget), however, there is no indication from this study that view graph transparencies would enhance student learning in any significant way.

It must be recognized that this study was severely limited. Each teaching mode was tried only one time for each course. Consequently the influence of the particular course objectives and content, instructor characteristics and room configurations could not be removed from the findings.

For a future test of teaching mode effectiveness the investigators believe it would be wise to run a laboratory study of these same parameters, to compare with the basically clinical study presented here. In particular it seems clear that there must be a greater commitment on the part of the cooperating participants to engage seriously in the study than was possible in this project through invitation and persuasion alone.

An alternate, and perhaps ultimately more effective follow-on study would be to extend the same clinical research methods and parameters to a much wider (and more random) sampling of the population of technical short courses given by UCLA and other institutions. One could then draw more valid conclusions applying the study results to adult learning.

II. Introduction

This study on "Evaluation of Short Course Method of Instruction for Practicing Professionals in Engineering" was first proposed just 28 months ago. Its intent was to be responsive to items (2) and (6) in the "Studies" section of NSF Proposal Solicitation 78-58, "Continuing Education for Scientists and Engineers," viz.

> "(2) Studies leading to the generation of validated criteria for measurement of the effectiveness of particular techniques or methods of delivery of continuing education,
>
> (6) Investigation of the learning patterns of adults, with particular emphasis on comparison of learning styles (and appropriate teaching styles) of adult scientists and engineers with their undergraduate and graduate-level counterparts."

The objective of the study was to investigate whether a statistically significant difference in adult learning occurred as a result of using two different instructional methods, viz. blackboard (BB) and view graph (VG). The population to be studied was the nation-wide body of professional engineers and scientists who attend short courses such as those given by UCLA Extension. Such short courses are usually given in a "total immersion" mode, concentrating about 30 contact hours of lecture in five days of full-time working hours contact.

Participants in short courses are invariably sponsored by their employers. Since the expense of attending, including the course fee, travel and per diem expense, plus having the individual off-station for the week, short course participants are generally well-positioned in their organizations. Motivations for attending short courses vary widely, ranging from the desire of management broadly to acquaint someone in the organization with new developments in a particular field to the keen desire of a younger professional to learn everything he can about the subject, with a view to putting it all to work the following week. It is a particular characteristic of short courses that all of the motivation to learn must come from within the individual, for there are usually no examinations given or requirements for homework to be done.

In conducting a study of this nature, therefore, one cannot count on anything like a uniform level of motivation to learn, let alone to engage in this study. It was in recognition of this fact that the original proposal specified a subsidy of $50 to each participant willing to engage in the study, which would involve taking four tests (pretest, posttest and follow-up tests at five weeks and four months after the course). This plan was sharply rejected by reviewers of the preliminary proposal, however, and the final proposal and subsequent study went forward with no more impetus to cooperate than the persuasive powers of the program managers and instructors.

The reader is referred to the project proposal to be found in Appendix 1. The project summary and narrative state the background need for a study of this type and how it was envisioned to be carried out. Briefly, two short courses of similar character were selected for the comparison of blackboard vs. view graph methods of presentation, "Digital Filters," coordinated and taught by Dr. Richard W. Hamming of the Naval Post Graduate School, and

"Kalman Filtering," coordinated by Dr. Joseph L. LeMay of Aerospace Corporation and taught by Dr. LeMay and Prof. William L. Brogan of the University of Nebraska.

Each course was to be given twice in the study, once using the blackboard exclusively and the other using extensive view graph projections (between 20 and 40 transparencies per 90-minute lecture). Each course was to be offered on the east coast at the University of Maryland and on the west coast at UCLA. Most important, the subject matter of the two courses was mathematics-oriented in each case, so that the participant samples drawn from the overall population would have a fair chance of yielding similar results. Since both east and west coast offerings were publicized nationally -- and since short course participants characteristically attend one location or another depending not on venue but on calendar -- it was assumed that the samples would yield no geographical bias, and the results tended to confirm this.

The final proposal was submitted to NSF June 9, 1978 and UCLA was notified of approval in September, allowing work to begin before the formal starting date of April 1, 1979 if desired. The project director attended a seminar sponsored by NSF in February, 1979 and became acquainted with the project monitor, Dr. Gene d'Amour of the Education Directorate in NSF.

The course coordinators prepared the questions for the test instruments (included in Appendix 2) as well as the view graphs for their visual presentations during the spring of 1979. The four test classes were given between July 29 and September 14, 1979, according to the schedule in Table 1 of Section III, the report from the Center for the Study of Evaluation.

Each test class had an observer -- a graduate student in the field of education -- sit through all sessions and make an audio cassette recording of a representative part of each offering. Each short course had the same observer for both modes of instruction, which meant considerable travel for the observers because each course was given at both University of Maryland and at UCLA.

The detailed assembly of test items into pretest, posttest and follow-up tests at five weeks and four months, as well as the administration of the tests and interpretation of results was accomplished by the Center for the Study of Evaluation at UCLA. Betty Johnson, Research Associate in CSE, was the person who followed the project from beginning to end. Section III of this volume is basically her report, with minor editing by the project director.

During the formative period of the project -- as well as during the time the proposal was being prepared -- periodic meetings were held with representatives of the Center for the Study of Evaluation, the course coordinators and the project consultant, Dr. Merlin Wittrock of the Graduate School of Education at UCLA. Once the operational guidelines and content of the test instruments were well established, however, there was little need of meetings until the data commenced to come off the computer, in the spring of 1980. There was, however, a need for continuous communication between the CSE research associate, Betty Johnson, and the project director.

A number of delays caused postponement of closing out the project on its original schedule, March 31, 1980. All of the cognitive test items, for example, had to be graded by the instructors, and none was to be touched until all of the instruction was completed (and most of the follow-up study as well). Additionally, it was believed for a time that the materials resulting from one of the test classes given at the University of Maryland had become lost in the mail, and a complete repeat study was organized and administered to a class of the same course, and the same mode, as the one feared lost. Some time later the missing materials came to light, and the repeat study was scrapped for lack of time to pursue it.

On March 3, 1980, the project director wrote to NSF, requesting a 90-day no-cost extension to the project, which could not be granted because it was not requested within the allowable time frame. The normal 90-day period following the closing of the grant would be available for finishing the final report. In point of fact it has only been possible to complete writing of the report in this period, and the printing must take place after the final closing date of June 30, 1980. The project director has been in continuous contact with the NSF monitor on the nature and extent of these delays.

Note on differences between proposal and project as implemented

It is important to understand that there are several aspects of the project which differed in the implementation from what was proposed. These are not considered significant in their effect on the observed results but they should be delineated here, viz.

1. Materials distributed to participants: The original proposal indicated that students in the blackboard mode would receive lecture notes, while the students taking the course by view graph would have no lecture notes but rather copies of the transparencies, on which they could make

notes. Later it was determined that it would unfairly disadvantage students in the view graph mode to withhold from them the textbook (or lecture notes) given the blackboard students. It was further originally proposed that responders to the follow-up questionnaires would be given a set of the notes or view graphs that they had missed, so that ultimately all of the cooperating students would have a complete set of handout materials, for the class as taken and for the alternate mode as well. The actual materials given to participants were:

Digital Filters		Kalman Filtering	
Blackboard	View Graph	Blackboard	View Graph
Textbook	Textbook	Lecture Notes (in lieu of text)	Lecture Notes (in lieu of text)
Notes on additional chapter	Notes on additional chapter		
	Transparencies		Transparencies

Owing to a misunderstanding the first Kalman Filtering class in the view graph mode were given neither a textbook nor the lecture notes on the first day of class. This situation was corrected before the second day so that all students in both modes had textbook (if there was one) plus lecture notes. One may feel that the students in the blackboard mode were disadvantaged not to receive the transparencies, but in point of fact the transparencies contain no information that is not included in the text or lecture notes. Thus it was not considered fruitful to issue the transparencies except as adjunct to the lecture presentation in that mode.

2. Exclusive use of blackboard or view graphs: It was originally intended (and the proposal pledged) that the one set of students would be

instructed exclusively by blackboard while the other set would be taught exclusively by overhead projector, supplemented only by the human voice in both cases. This turned out to be exactly true only in the case of Dr. Hamming and the blackboard mode. In that class there were indeed no visual aids other than the blackboard. In Dr. Hamming's view graph presentation, there were occasional questions from the class, and he would often turn to the familiar blackboard in order to answer them.

In the case of Dr. LeMay's blackboard class, he asked to be allowed to use just two visuals, by way of overview, at the beginning of each lecture. Although this was felt to be a slight adulteration of the test, it was not really possible to say him nay because the overall integrity of the course and the satisfaction of students (and instructor) were of a priority equal to that of the project, since the students were not being subsidized in any way.

3. Admission to the test classes: The proposal spoke of withholding admission to the class from a participant who did not choose to take the tests and join in the study. This might have been done had there been a surplus of course applicants. In fact it was possible to accommodate all applicants in the classrooms, and so there was no restriction on admission. While most of the students did choose to go along with the study, some did not, and there was no way of forcing them, of course, to comply. All in all, the project is probably fortunate that the cooperation was as good as it was, considering especially that there was no subsidy or monetary incentive for participation.

4. "Conventional" linear approach vs. visual analogue approach: The proposal spoke a good deal of a difference in presentations between black-

board and view graph, arising not only from the use of the different forms of visual aid, but also from the order of presentation. It was stated, for example, that the blackboard lecturer would follow a conventional, linear, sequential approach, building the theory block upon block, "teaching the student how to learn," etc. The view graph lecturer, on the other hand, would subject the student to a simultaneous array of fact, theory, application and example; he would learn to understand the ways in which these elements of new knowledge are organized and related to one another.

However good this idea may have been in theory, it simply did not work in practice. Each of the instructors had taught his course a number of times and knew what worked with the students for this type of mathematical material: the linear block-upon-block approach. Thus (with the exception of Dr. LeMay's two introductory transparencies for each lecture) the sequential order of presentation was the same for all courses and both instructors.

5. Testing by mail: It was suggested in the proposal that the testing at all times would best be achieved by mail. As the realities of sending the tests out and back became clear, it was decided to take advantage of the physical presence of the students on campus to get the pretest and posttest completed with a minimum of effort. As noted elsewhere, even with this convenience there were some who simply chose not to participate. Based on the difficulties experienced in retrieving the follow-up questionnaires, furthermore, it is doubtful whether a mail response type of contact would have yielded enough valid results to conduct the study at all.

As it was, the response to the follow-up questionnaires was so small that it was impossible to draw any conclusions of statistical significance from the results.

6. Dissemination of Project Results: Although not a departure from the proposal plan, it can be noted here that the project director has been invited to present a paper based on this project at the forthcoming College Industry Education Conference of the American Society for Engineering Education, to be held January-February, 1981 in Orlando, Florida. The sponsoring organization will be the Continuing Professional Development Division of the ASEE.

A Note on Statistical Measures Used

The "Statistical Package for the Social Sciences" (SPSS) was utilized for all data analysis. This is a packaged set of statistical programs which is available in the UCLA computer. The symbols used in the text/report/ tables are:

$\overline{X}$ -- mean/arithmetic mean

SD -- standard deviation

F -- F statistic (ratio of variances, in statistical tables)

Of the greatest importance in these studies is the statistical significance (Sig) level, which measures rejection of the null (or equivalence) hypothesis. Significance levels (sometimes called confidence levels) are reported in the tables and report as decimals, e.g. .097. Although there is no universally accepted level for rejecting the null hypothesis, the .05 significance level is not uncommonly selected as the criterion.

In comparing two population samples on a particular characteristic or measure, one may find a difference in the means of the samples of, say $\overline{X}_1 - \overline{X}_2 = \overline{X}_d$. If this difference is very small it may appear that the two samples are indeed random samples from the same population. In such instance the actual calculation of the significance level might yield, for example, .50, which would mean that a difference this large (or larger) would occur by chance 50% of the time. Smaller differences have a higher chance of occurring naturally, and larger differences a lower chance.

While the uninitiated might tend to think of the .50 statistical significance level as a reasonable point to question the null hypothesis, the professional statistician selects a much lower figure (on the order of .05) on which to base any conclusion rejecting the null hypothesis. In summary, then, a "statistically significant difference" between the means of two samples occurs when the observed difference is calculated to occur naturally in 5% (or fewer) random samples from the same population.

III. Report of the Center for the Study of Evaluation

by Betty Johnson, Research Associate

Evaluation Procedures

Two short courses were used in this study: Digital Filters (DF) and Kalman Filtering (KF). Each course was presented two times (i.e., in two classes). The presentations differed only in the use of the blackboard (BB) or view graphs (VG) to present visual material. The order and location of the classes was varied. One class of each short course was presented at UCLA and the other at the University of Maryland.

TABLE 1

ORDER AND LOCATION OF CLASSES

	DIGITAL FILTERS (DF)		KALMAN FILTERING (KF)	
TEACHING METHOD	Los Angeles	Maryland	Los Angeles	Maryland
Blackboard (BB)		1st (July 29-Aug. 3, 1979)	1st (Aug. 26-31, 1979)	
View graph (VG)	2nd (Aug. 19-24, 1979)			2nd (Sept. 9-14, 1979)

The instructors had each taught their short courses several times and had prepared the reference materials (textbook or class notes) as well as the view graphs. The class structure and format were well established and the instructors were able to keep the two classes very similar in order and content of presentation.

An observer sat in on each class to determine if there were any observable differences between the two classes other than the mode of visual presentation. The observer also administered the pretest and posttest and handled any administrative problems which arose.

The observers looked for differences in the instructors' mode of presentation or in the students' reaction to the course. Each observer sat in on both modes of the same course. Detailed reports submitted by the two observers are included in Appendix 4.

The students each received either class notes (KF) or a textbook (DF) supplemented by notes for one additional chapter. These materials were written by the instructor and closely paralleled the organization of the course. In addition, the students in the view graph classes received a notebook containing copies of the view graphs. One departure from this procedure occurred in the Maryland Kalman Filtering (VG) class. Owing to a misunderstanding students did not receive copies of the class notes when they registered. These materials were provided by the end of the first day, but some hostility developed as a result of the delay.

Evaluation Measures

Four measures were administered as part of this study. They included pretest, posttest, and two follow-up instruments. Each measure included items to assess the students' opinions of the instruction as well as items to measure achievement of the learning objectives.

Each instructor prepared a series of questions to assess achievement of the learning objectives for his courses. The items covered introductory background material as well as specific course objectives. Items were selected from this pool to form a pretest, a posttest and two follow-up tests. The pretest was primarily composed of items assessing knowledge of background material. The posttest and follow-up tests were composed primarily of items which measured learning objectives for the short course.

Copies of all test and questionnaire instruments are found in Appendix 2.

Prior to the class the students received a letter explaining that a study in the effectiveness of short course instruction was being conducted and inviting them to participate. They were asked to come the Sunday evening prior to the beginning of the class for a free dinner and a special presentation by the instructor. The presentation was adjunct to the material in the course in the case of the Digital Filters course and in the Kalman Filtering course it comprised the introductory lecture. At that time they were reminded that a study of short course instructional effectiveness was being conducted and they were asked to complete the pretest. Students who were unable to attend the Sunday evening session were asked to complete the pretest at their earliest convenience on Monday.

The posttest was administered before lunch on the final day of each class (Friday). Pretest and posttest measures were completed in approximately 45 minutes each. There was no attempt made to limit the time spent by participants in answering the questions, but all finished in the allotted time.

Follow-up questionnaire 1 was mailed to the participants five weeks after completion of the course. A follow-up letter was sent approximately three weeks later. The second follow-up questionnaire was mailed to participants four months after completion of the short course. A second copy of the questionnaire was mailed three weeks later. The participants were asked to complete the follow-up questionnaire on a closed-book basis, working only from memory.

Population Sample

The sample for this study included two engineering short courses of similar character, viz., highly math-oriented. Each course was taught two times by the same instructor. One class was taught by blackboard (BB) and one by view graph (VG). The students in each class were asked to participate in the study by completing pretest, posttest and two follow-up questionnaires. Although the classes were each given on the east and west coasts, it was assumed that the participant samples were random samples of the same population.

A number of students did not participate in the study. Some felt that since the short course does not provide an opportunity to work problems and receive feedback they were not prepared to answer the questions that appeared on the test. Several remarked that they knew where to find the material and were confident that they could use it but were not prepared to answer questions such as those on the posttest.

The students were asked to write a seven-digit ID number on each instrument. This was intended to insure the anonymity of the respondents. However, the procedure resulted in some loss of data because a number of the participants either failed to write a number on their instruments or forgot the number in the course of the study.

The number of respondents was also diminished because some students did not wish to complete the problem section of the test. It was not possible to distinguish between those who could not answer any question and those who chose not to do so. Consequently all blank papers were eliminated from the study.

The final sample includes all students who attempted all questions on the pretest and the posttest. Response to the follow-up questionnaires was limited and considered to be of much less significance than the pretest and posttest responses.

Results - Pretest and Demographic Analysis

Pretests were administered to check the (null hypothesis) assumption that the blackboard and view graph classes could be assumed to be random samples from the same population. The pretest included demographic data (college major, highest degree, job area, job type, and reason for taking the course) as well as a cognitive test of the background information required for understanding the course. The results of the pretest are presented in Tables 2 and 3.

TABLE 2

PRETEST SCORES

Class	Mode	n	$\overline{X}$	SD	F	Sig
Digital Filters	BB	32	25.06	18.78	4.465	0.0393
	VG	23	15.78	11.71		
Kalman Filtering	BB	55	30.25	18.37	0.001	0.9786
	VG	22	30.14	14.77		

The mean pretest score for the Kalman Filtering blackboard class was 30.25. The mean score for the view graph class was 30.14. A difference at least this large will occur by chance 97.9% of the time. Thus, the pretest scores do not provide any reason to question the assumption that the two Kalman Filtering classes are samples from the same population (i.e. the null hypothesis is not rejected).

The mean pretest score for the Digital Filters view graph class was 15.8. The average pretest score for the blackboard class was 25.1, 10 points higher. This difference is statistically significant at the .039 level. A difference this large leads us to question the assumption that these classes are random samples of the same population.

Analysis of the demographic variables does not provide a conclusive explanation for this difference. The classes are similar in the proportion of higher degrees and the distribution of major fields. The blackboard class was slightly younger which suggests that they may have better facility with mathematics since they have been in school more recently. Further, the blackboard class was employed more in research (also more in government employment) while the view graph class was employed more in technical design and management (also more in industry). See Table 3.

In any event, the study is not vitiated by this statistical difference, since results are based on the gain of information by the student, not the absolute amount before or after the course.

TABLE 3

DEMOGRAPHIC DATA ON COURSE PARTICIPANTS (STUDENTS)

	Kalman Filtering		Digital Filters	
	BB (n=52)	VG (n=22)	BB (n=25)	VG (n=23)
Highest Degree				
Ms	20.0%	27.8%	50.5%	52.2%
BS	60.0	44.3	31.3	30.4
Ph.D.	20.0	27.8	18.8	17.4
College Major				
Math	13.9	16.5	6.3	4.8
EE	23.8	41.8	50.0	42.9
Physics	19.0	8.9	6.3	23.8
Other Engineering	1.6	5.9	12.5	9.5
Other	27.0	24.1	25.0	19.0
Job Area				
Industry	67.7	32.5	44.8	56.5
Government	22.6	50.6	48.3	30.4
Education	4.8	6.5	3.4	0.0
Private	0.0	1.3	3.4	4.3
Other	4.5	9.1	0.0	8.7
Job Type				
Technical Design	50.0	13.0	22.6	38.1
Research	30.8	58.0	61.3	42.9
Management	11.5	13.0	3.2	14.3
Operations	4.3	4.3	9.7	4.8
Sales	0.0	1.4	3.2	0.0
Education	0.0	5.8		
Reason for Taking Course				
Introduction to Theory	7.9	14.5	0.0	5.0
Review	19.0	9.2	13.3	10.0
Learn Applications	30.2	25.0	26.7	20.0
Learn Language	7.9	3.9	6.7	5.0
Gain Overview	1.6	10.5	6.7	5.0
Teach	1.6	0.0		
Other	14.4	36.8	46.7	55.0
Year of Graduation			70	69

Results - Affective Response and Suggestions for Improvement

The posttest and follow-up questionnaires were administered to examine the students' perception of the effectiveness of the two teaching methods as well as their achievement of the learning objectives for the course.

The students' opinions of the effectiveness of the instructional modes are presented in Table 4. In general the ratings of the effectiveness of the blackboard and view graph presentations were very similar. There were no statistically significant differences in the ratings of the Kalman Filtering classes. Significant differences in the ratings of the Digital Filter classes occurred only for quality of the visual presentation and contribution of the visual presentation to course understanding. The view graph class rated each of these aspects of the presentation higher than the blackboard class.

The students' suggestions for improving the effectiveness of the instruction and the observers' reports provide some indication why these differences in the rating of the visual presentation may have occurred and why the same differences did not occur with Kalman Filtering classes. The observer's report indicates that the configuration of the room in which the Digital Filter blackboard class was taught made it difficult to see the blackboard from some parts of the room. In addition, the instructor wrote small and had a tendency to block the material he was writing with his body. The students' suggestions for improving the effectiveness of the instruction also noted this difficulty. Students in the view graph class commented that they preferred view graphs to the traditional blackboard mode of presentation.

TABLE 4

STUDENTS' OPINIONS OF SHORT COURSE INTRUCTION

Item: Five Point Scale: 5=excellent 1=unsatisfactory		Digital Filters		Kalman Filters	
		BB n=29	VG n=23	BB n=49	VG n=18
Clarity of presentation	$\overline{X}$	4.10	4.39	4.32	4.65
	SD	0.77	0.72	0.74	0.48
	F	1.887		3.366	
	Sig	0.1757		0.0709	
Continuity and order of presentation	$\overline{X}$	4.48	4.39	4.20	4.15
	SD	0.57	0.78	0.72	0.49
	F	0.236		0.069	
	Sig	0.6292		0.7939	
Speed of delivery 1=much too fast 3=just right 5=much too slow	$\overline{X}$	2.24	2.32	2.71	2.65
	SD	0.74	0.48	0.73	0.59
	F	0.180		0.093	
	Sig	0.6732		0.7608	
Ability to hold attention and interest	$\overline{X}$	4.45	4.70	4.16	4.26
	SD	0.74	0.47	0.77	0.73
	F	1.958		0.256	
	Sig	0.1679		0.6148	
Quality of visual presentation	$\overline{X}$	3.16	4.26	3.84	3.84
	SD	0.99	0.81	0.74	0.69
	F	17.669		0.000	
	Sig	0.0001		0.9914	
Contribution of visual presentation to your understanding	$\overline{X}$	3.48	4.06	2.94	3.11
	SD	0.82	0.77	0.71	0.57
	F	5.992		0.823	
	Sig	0.0182		0.3675	
Did the course provide adequate preparation so that you could use Kalman/Digital filters in your work?	$\overline{X}$	2.34	1.96	3.80	4.06
	SD	0.94	0.77	0.89	0.54
	F	2.578		1.34	
	Sig	0.1146		0.25	

TABLE 4, CONTINUED

Item: Five Point Scale: 5=excellent 1=unsatisfactory		Digital Filters		Kalman Filters	
		BB n=29	VG n=23	BB n=49	VG n=18
Presentation of background material	$\bar{X}$	4.03	4.00	4.71	4.50
	SD	0.78	0.74	1.04	0.89
	F	0.026		0.604	
	Sig	0.8718		0.4398	
Theory development	$\bar{X}$	4.03	4.26	4.12	4.00
	SD	0.91	0.81	0.86	0.58
	F	0.879		0.301	
	Sig	0.3530		0.5851	
Examples	$\bar{X}$	3.62	3.52	4.06	3.95
	SD	0.98	1.03	0.73	0.60
	F	0.124		0.348	
	Sig	0.7260		0.5574	
Applications	$\overline{XX}$	3.64	3.16	3.92	3.90
	SD	0.95	0.17	0.82	0.72
	F	2.861		0.011	
	Sig	0.0972		0.9183	

The students' suggestions for improving the effectiveness of the Kalman Filtering class included some comments on the quality of the view graphs. The view graphs were prepared for this study and the instructor had taken advantage of the option to use color in several of the view graphs. The colored view graphs were difficult to see. The students' ratings may reflect the quality of these materials rather than their impression of the effectiveness of view graphs as an instructional technique.

Results - Posttest at End of Short Course

Analysis of the posttest scores for the Kalman Filtering class (see Table 5) did not reveal any statistically significant differences between the two teaching methods. The mode of visual presentation did not appear to influence the students' achievement of the course objectives.

The posttest scores for the Digital Filter blackboard class were significantly higher than the scores for the view graph class. The average posttest score was 72.2 for the blackboard class and 57.5 for the view graph class. This difference is statistically significant at the .01 level. However, the meaning of this difference is not clear since the pretest scores of this class were also significantly different.

TABLE 5

POSTTEST SCORES

Class	Mode	n	$\overline{X}$	SD	F	Sig
Digital Filters	BB VG	32 23	72.22 57.61	16.99 24.21	6.930	0.0111
Kalman Filtering	BB VG	55 22	35.38 32.55	15.57 14.22	0.547	0.4620

Pretest scores were employed as a covariate in an attempt to remove the influence of the students' prior knowledge. See Table 6. This analysis did not find the difference in posttest performance between the two teaching methods to be statistically significant. This suggests that the posttest differences were the result of differences in educational background or work experience rather than teaching methods. Students having more facility with mathematics appear to have been better able to grasp the concepts which were presented in the course. The influence of prior knowledge on achievement may be especially apparent in courses taught by the short course format since there is no provision for practice exercises or feedback and most students spend little time studying outside of class.

TABLE 6

COVARIANCE ANALYSIS OF DIGITAL FILTER SCORES

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Signif of F
Covariate/	5638.195	1	5638.195	14.330	0.000
Pretest Scores	5638.195	1	5638.195	14.330	0.000
Main Effects/	713.703	1	713.703	1.814	0.184
Teaching Method	713.700	1	713.700	1.814	0.184
Explained	6351.898	2	3175.949	8.072	0.001
Residual	20458.992	52	393.442		
Total	26810.891	54	496.498		

Results - Note on Self Assessment in Digital Filters Course

A number of students did not attempt the problem tests. Their comments suggested that some did not have adequate mathematical facility (current practice) to complete the presentation. In addition, differences in reasons for taking the class seemed to influence the level of understanding which the students attempted to achieve. Since the short course format does not provide exercises and feedback to facilitate learning, differences in achievement may be greater than for other types of classes.

A self assessment measure was used in the Digital Filter course in addition to the problem test. It asked the students to assess their level of learning for each of the course objectives. (See instruments in Appendix 2) This instrument contained three levels of understanding for each of 25 objectives. It had the advantage that it could be completed quickly and more students were willing to complete it. It had the potential disadvantage that students would overestimate their ability to perform certain tasks or be unwilling to appear "dumb." The results of this measure are presented in Tables 7 and 8. The direction of the results is consistent with those of the problem tests. However, the differences in self assessment between the blackboard and view graph classes are less dramatic. There are several possible reasons for this. The self assessment measure includes three levels of understanding and therefore there should be more items which each student can do than on the problem test which contains only items from the highest level of learning problems. It may also have some inflated results for students who are unwilling to appear in an unfavorable light or who do not really understand what the problem involves.

The self report measure may provide an effective method for assessing the effectiveness of short courses. The scores correlated .55 with the pretest and .57 with the posttest. This correlation would presumably be higher if the two covered the same sample of learning tasks. (The self reassessment measure covered a wider range of learning tasks).

TABLE 7

PRETEST SCORES FOR DIGITAL FILTERS CLASSES

Measure		Teaching Method		
		Blackboard		View Graph
Self Assessment	$\overline{X}$	150.88		143.92
	SD	26.15		19.30
	F		1.756	
	Sig		0.1891	
Problem Test*	$\overline{X}$	24.70		15.78
	SD	18.60		11.17
	F		4.208	
	Sig		0.0451	

TABLE 8

POSTTEST SCORES FOR DIGITAL FILTERS CLASSES

Measure		Teaching Method		
		Blackboard		View Graph
Self Assessment	n	38		37
	X	199.26		198.41
	SD	15.91		11.87
	F		0.070	
	Sig		0.7925	
Problem Test*	n	32		23
	$\overline{X}$	67.02		57.57
	SD	20.51		24.18
	F		3.402	
	Sig		0.0691	

*These results differ slightly from those reported earlier because this analysis used entire sample. The earlier analysis was limited to those students completing the problem section of the pretest and posttest.

Results - Follow-up Questionnaires

The students' evaluation of the course at the five-week and four-month follow-up are presented in tables 9 and 10. The ratings follow the same general pattern as the posttest. The Digital Filters view graph class was rated higher than the blackboard class on every item. However, none of these differences reached the .05 level of significance and both classes were evaluated favorably. The probability that one teaching method would be rated higher on all four items if there were no difference in the students' attitudes toward the two teaching methods is .0143. Thus, while none of the individual differences is statistically significant, the four together appear to show a significant preference for the view graph method.

There was no consistent pattern for the Kalman Filtering class. The view graph class was rated higher in some aspects and the blackboard class was rated higher on others.

The participants' recommendations for improving the effectiveness of instruction focused more on the content of the instruction than the form of presentation (e.g., what rather than how). A number of students felt they did not have adequate background to understand the development. They recommended more review of the "tools" needed, possibly including a pre-session. Other suggestions for improving the effectiveness of instruction included: (1) provide more examples of applications worked out in more detail; (2) provide a wider range of applications; (3) provide some "hands on" experiments with simulated problems; (3) use more view graphs to save time (KF BB).

TABLE 9

FOLLOW-UP 1 COURSE EVALUATION (5 WEEKS)

Item: Five Point Scale 5=Excellent 1=Unsatisfactory		DIGITAL FILTERS		KALMAN FILTERING	
		BB (n=8)	VG (n=12)	BB (n=13)	VG (n=4)
How do you rate the Digital/Kalman Filter Short Course at this time?	$\overline{X}$	4.25	4.42	4.38	4.00
	SD	1.04	1.79	0.65	0.82
	F	0.166		0.959	
	Sig	0.6881		0.3430	

TABLE 10

FOLLOW-UP 2 COURSE EVALUATION (4 MONTHS)

Item: 5=Excellent 1=Unsatisfactory		DIGITAL FILTERS		KALMAN FILTERING	
		BB (n=4)	VG (n=9)	BB (n=16)	VG (n=7)
Content	$\overline{X}$	4.25	4.78	4.56	4.57
	SD	0.50	0.44	0.63	0.53
	F	3.680		0.001	
	Sig	0.0814		0.9743	
Presentation	$\overline{X}$	4.25	4.78	4.37	4.67
	SD	0.96	0.44	0.62	0.53
	F	1.971		0.529	
	Sig	0.1880		0.4752	
Materials	$\overline{X}$	3.75	4.56	4.31	4.29
	SD	0.50	0.73	0.60	0.76
	F	3.976		0.008	
	Sig	0.0716		0.9284	

Follow-up scores on cognitive questions (problems) are presented in Tables 11 and 12.

Few students were willing to spend time to complete the problems on the follow-up questionnaires. Several comments on the questionnaires stating that they had not used the material or studied it since completing the short course and therefore were not prepared to answer the questions. They expressed confidence that they could achieve the necessary knowledge and facility with procedures by studying the references material and notes.

The scores of those who did complete problems had a large variance, although no greater than for the pre- and post- tests. Some were well acquainted with concepts and mathematics and answered most questions correctly. Others attempted few problems and those tended to be only partially correct.

The small number of students completing the follow-up measures makes it difficult to reach any conclusions about the influence of the teaching mode on retention. In addition, the sample is not representative of the achievement of the entire class, since so few participants responded.

TABLE 11

FOLLOW-UP SCORES FOR DIGITAL FILTER CLASSES

Measure		Teaching Method		
		Blackboard		View graph
4 Week Follow-Up	$\overline{X}$	52.33 (n=12)		46.23 (n=13)
	SD	22.27		25.34
	F		0.406	
	Sig		0.5302	
4 Month Follow-Up	$\overline{X}$	65.40 (n=10)		38.50 (n=10)
	SD	19.97		23.87
	F		7.473	
	Sig		0.0136	

TABLE 12

FOLLOW-UP SCORES KALMAN FILTER CLASSES

Measure		Teaching Method		
		Blackboard		View graph
5 Week Follow-Up	$\bar{X}$	42.53 (n=15)		40.33 (n=3)
	SD	18.13		20.31
	F		0.036	
	Sig		0.8526	
4 Month Follow-Up	$\bar{X}$	36.06 (n=17)		26.67 (n=6)
	SD	16.60		10.76
	F		1.647	
	Sig		0.2134	

Observations

The observers reported that the content and organization of the classes did not change significantly as a result of varying the teaching mode. The topics covered, the sequence of presentation, the type of explanation, and the time spent on each topic were very similar for the two teaching methods.

Some variations were noted in the speed of presentation. The use of view graphs reduced the time required to present an equation because neither the instructor nor the student needed to write the equation. Many students took notes directly on the view graphs. However, the differences in speed of presentation and note taking were not as great as they might have been because the instructors followed the reference materials closely and sometimes asked the students in the blackboard class to refer to equations in the reference material rather than writing them on the blackboard. The Digital Filters blackboard class followed whole chapters in the book, thus achieving a presentation much like that of a view graph. The students also made notes directly in the class notes or text. The amount of note taking in both modes was not great because all of the major equations were in the text and the presentation closely paralleled the text. The Digital Filter blackboard class did have a more thorough development of some mathematics than the view graph class. The instructor sometimes included intermediate steps in his blackboard development that were not in the text or view graphs. These equations were not included in the view graph class.

Student comments about the Digital Filters view graph class were extremely positive. A number of students made coments that they preferred view graphs. The Kalman Filtering view graph class was less satisfied. Part of this may be explained by (1) quality of some view graphs (2) delay in providing notes, which created some initial hostility. Audio cassette tape recordings were taken of representative parts of each class. These cassettes are available on request to qualified users.

Conclusions

Blackboard and view graph presentation appear not to reveal a statistically significant difference in achieving learning objectives for courses taught in the short course format. There were no significant differences in student achievement which could be related to differences in the mode of visual presentation.

Student satisfaction was also similar for the two teaching modes. There appears to be a tendency to favor the view graph mode of presentation because of greater visibility and ease of note taking. However, the extent of this difference was obscured by the nature of the rooms and materials used in this study.

The differences in the quality of view graphs and classrooms which occurred in this study are typical of the range of situations which occur in general. They point out conditions which may indicate the use of one mode of visual presentation. For example, in situations where the room configuration makes it difficult for some students to see the blackboard view graphs may be used to overcome the visual deficiencies. The students' expressed preference for the view graph mode of presentation may also be sufficient reason to undertake the expense and effort of producing view graphs for classes which will be taught several times. On the other hand, since there does not appear to be any significant difference in learning resulting from the mode of visual presentation the additional cost may not be justified for classes which will be taught only one time.

The scope of this study was limited. The blackboard and view graph methods were compared in two short courses. Both of these were technical courses involving the presentation of mathematical equations. Each teaching mode was tried one time for each class. Consequently, the influence of the particular course objectives and content, instructor characteristics, and room configurations could not be removed from the findings. There may be learning tasks and conditions for which one teaching method is more effective.

IV. DISCUSSION

Several points of discussion relating to the difference between the study as proposed and the study as implemented are presented in the last part of the Introduction, Section II. Further discussion is included intermittently in Section III, the report of the Center for the Study of Evaluation. A few additional matters can be discussed in overview at this time.

Difference in the Test Items Between the Two Short Courses

It was observed by the CSE Research Associate, Betty Johnson, that the nature of questions asked by Dr. Hamming (Digital Filters) was inherently different from those asked by Dr. LeMay (Kalman Filtering). Dr. Hamming asked questions that required problems to be solved, with mathematical answers that were either right or wrong, wheras Dr. LeMay's questions were more conceptual in nature. Dr. Hamming explained that he had made the questions completely objective on purpose, so that they could be graded without any judgment on his part that could be influenced by extraneous factors (like an inherent desire to see the test succeed). It was of course of no material significance that these questions were different, since each course was evaluated in its two modes independently of the other. Nevertheless, the results from both courses essentially reinforced one another, which tends to verify the evaluation procedure.

The Age Factor

It was noted earlier that a possible explanation for the superior performance of the blackboard class in Digital Filters was that they were slightly younger, about four years difference in average date of graduation. The data show the following:

Teaching Method	Group Completing Pre Test			Group Completing Pre and Post Tests		
	Mean Year of Graduation	n	SD	Mean Year of Graduation	n	SD
BB	70	42	6.83	72	32	5.26
VG	69	37	7.99	68	23	9.19

The year of graduation ranged from '48 to '79, and the mean, mode, and median years were '70, '71 and '72 respectively. It is interesting that the "dropouts," i.e. those who for one reason or another did not take the posttest (10 in the case of the blackboard and 14 in the case of the view graph class) tended to be older than average in the blackboard class and younger than average in the view graph class. Owing to their more recent familiarity with classroom mathematics, this might help to explain why the younger class did better on the posttest.

It does not explain why the dropouts in one group appear to have been the older ones (which seems logical, in view of their interests centering more toward management) while the dropouts in the view graph class were evidently younger than average. The higher standard deviation for the view graph class also shows that there were more of the older ones in the view graph class (than there would have been with the same mean and a smaller standard deviation), and this might have some bearing.

The age factor also doesn't account for the difference in performance on the pretest of these groups. The earlier explanation, that the blackboard group was more predominantly employed in research, while the view graph group was employed more in design and management, suggests the more likely explanation.

Need for Additional Study

Although the results of this clinical study appear to show no statistically significant difference in adult learning depending on the two modes of instructional delivery, there is good reason not to abandon further study. The limitations of statistical measures applied to learning are well known to researchers in the field of education. Further, the samples used in this study were not large enough to draw firm conclusions, and the study included no truly confirming data in which the same experiment was repeated in exactly the same way (in the same course, with the same instructor), to learn the normal distribution in this type of population.

To do more controlled research in this field would require a laboratory approach, where the subjects are paid (or more fully subsidized in the case of continuing education) and have an obligation to engage seriously in the research. Above all, it appears that true retention studies--involving the subjects responding to questionnaires by mail--must be aided by compensation or subsidy. The response from the volunteers in this study was so limited as to make any statistical conclusion highly suspect.

Perhaps ultimately the more effective follow-up study would be to extend the same clinical research methods and parameters to a much wider and more random sampling of the population of technical short courses given by UCLA and other institutions. One could then draw more valid conclusions applying the study results to adult learning.

Application to Evening Classes

It was noted by reviewers of the preliminary proposal, and also in the final proposal, that one would hope eventually to attack the question of comparing the short course intensive mode of instruction with that extended over 10 to 12 weeks, covering exactly the same material in the same number of instructional hours. With the experience gained in this study, the investigators are prepared to present a proposal, if encouraged, to undertake such a program.

The first approach would probably be taken on a semi-clinical basis, utilizing students who intend to take this material anyway, but engaging them in the study in advance--with subsidy--and establishing a substantial background profile of each participant in order that individual learning characteristics be duly accounted for in the analysis.

As noted in the proposal, the most difficult feature of this kind of study would be dealing with the inherent differences in evening classes tend to be the younger, and probably more highly motivated, employees, while those taking short courses are older and generally more established in mid-management positions. It will have to be assessed whether the objective is to learn about the differences in learning and retention beteen intensive and distributed instruction--with the same population--or whether to assess the overall effectiveness of these two modes, recognizing the inherent difference in populations.

APPENDIX 1

PRELIMINARY PROPOSAL

AND

PROJECT PROPOSAL

COVER SHEET **APPENDIX 1-A** SEDR/CESE

CONTINUING EDUCATION

PRELIMINARY PROPOSAL FOR ☒ STUDY ☐ CONFERENCE WORKSHOP ☐ OTHER

IN THE AREA OF ☒ ENGINEERING ☐ SCIENCE ☐ BOTH E&S

Evaluation of Short Course Method of Instruction for Practicing
Title of Project (Limit to 12 Words)
Professionals in Engineering

The Regents of the University of California
Institution or Organization

405 Hilgard Avenue, Los Angeles, CA 90024
Street Address City State Zip Code

Prof
[✓ Dr]
Mr
Ms

Alfred C. Ingersoll 225-28-0517
Project Director Social Security No.*

Continuing Education in Engineering and Math, University Extension, UCLA
Title, or Unit of Institution or Organization named above

March 2, 1978
Date of Submission

A. C. Ingersoll
Signature of Project Director

12 months
Estimated duration (months)

$ 75,000.
Estimated amount to be requested

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* Social Security numbers are used by the Foundation to monitor and facilitate the processing of numerous proposals, and to maintain award data. The number is solicited pursuant to the general authority of the Foundation under the NSF Act of 1950 as amended. Submission of social security number is voluntary and refusal to disclose a social security number will not affect an institution's eligibility for award.

March 2, 1978

National Science Foundation
Washington, D.C. 20550

Attention: SEDR/CESE

Gentlemen:

RE: Preliminary Proposal: "Evaluation of Short Course Method of Instruction for Practicing Professionals in Engineering"

This preliminary proposal is being sent on behalf of the Department of Continuing Education in Engineering and Mathematics, University of California, Los Angeles, and the Center for the Study of Evaluation, UCLA. It speaks specifically to Paragraph 2, under "Studies," page 2 of the solicitation, viz:

> "(2) Studies leading to the generation of validated criteria for measurement of the effectiveness of particular techniques or methods of delivery of continuing education."

The preliminary estimate of budget, for a 12-month study, in calendar 1979, is $75,000. A detailed breakdown of this estimate is given in Appendix A, attached.

Rationale for Proposed Project

The short course is one of the most highly developed, yet least studied, methods of delivery of continuing education in science and engineering in the United States today. For purposes of this proposal, a short course may be defined to be that mode of continuing education delivery in which a coherent body of subject material is treated in a formal classroom setting, with one or more specialists lecturing to a class of not more than 60 persons, for six to eight hours per day, for a period of 3 to 10 days (most commonly 5 days). The short course usually involves almost no learning reinforcement, evaluation of knowledge learned or skills acquired, and the communication is at a high level of sophistication.

Every year millions of dollars are spent by industry and government agencies in sending their scientists and engineers to short courses. To a considerable extent these are given through university extensions but a growing number of short courses are given by professional societies and entrepreneurial organizations. Fees charged for attendance at short courses are on the order of $100 to $150 per day and commonly the cost to the company sponsoring the attendee is between four and five times this when one counts travel, per diem expenses and replacement of the individual in his employment.

In contrast to the conventional "after-hours" type of continuing education delivery the short course has never involved much evaluation of the student's participation in the course. Conversely there is considerable evaluation of the course itself and of the instructors. Students and instructors alike seem to agree that a conventional examination is not a realistic method of evaluating learning in the short course mode. For one thing there is little or no opportunity for the student to engage in meaningful homework assignments (and to have them corrected and returned during the few days of the couse) and most instructors are reluctant to ask students to answer questions or work problems in an examination without prior homework on the subject.

Because the total expense of attending a short course is so high (and it usually runs between three and 20 times the cost of attending an after-hours course covering the same material), the participants have commonly come from the ranks of well established corporate technical management. With the ever-increasing requirements in industry and government for accountability, the demand for objective evaluation of the short course participant's learning experience is growing rapidly. It will be one purpose of this study to make a concrete step toward meeting this demand. A collateral objective will be that drawn from the solicitation, to generate validated criteria for measurement of the effectiveness of the short course technique in delivering continuing education.

The results of this study -- both as to evaluation of the short course participant's learning experience and as to the evaluation of this method of delivery of continuing education -- will be applicable to short course programs of continuing education given anywhere under conditions similar to those of UCLA Extension. There is nothing inherently peculiar to our method of delivery, selection of participants, or conditions under which a short course is given.

Methodology - Overview of Major Line of Attack

As presently conceived, the study will be conducted on two short courses, (see attached brochure, Appendix B, for 1978 offerings) given in the Summer of 1979, by the same instructor, Dr. Richard Hamming of the Naval Postgraduate School. The courses are Digital Filters and Coding and Information Theory. Each course will be given in three locations: UCLA, University of Maryland and University of Toronto. In each course the instructor is the same for the three offerings, and the subject material covered is the same.

By means of domain reference testing -- utilizing pre-testing, post-testing, and [illegible] retention testing at intervals up to four months -- the effectiveness of the two courses will be evaluated. The domain of competency in vocabulary, cognitive knowledge and problem-solving ability will first be identified by the instructor assisted by specialists in the UCLA Center for the Study of Evaluation. Test writers from the Center will then prepare a substantial pool of test items, from which the pre-testing and post-testing instruments will be constituted of items selected at random. In the case of one course, say Digital Filters, a well-defined instructional design will be utilized in the UCLA and University of Maryland offerings. It is envisioned that this test will show the nondistinctive character of the continuing education audience, i.e., the same measures of course effectiveness will obtain in the UCLA and University of Maryland offerings. When the same course is given at the University of Toronto, a different instructional design will be used to cover the same material. The same series of tests will be used to gage the effectiveness of this course offering, and it may be possible, then, to draw some tentative conclusion as to the comparative effectiveness of the two instructional designs.

In the other course, Coding and Information Theory, the same instructional design would be followed in the UCLA and Toronto offerings, with the alternate design pursued in the Maryland offering. Again it is expected that the UCLA and Toronto offerings would demonstrate a nondistinctive audience, while the Maryland course would reveal the relative effectivness of the two instructional designs.

Expected Project Outcome

If the two courses yield the same relative comparison between the two instructional designs -- as we hope -- then, clearly, we are on our way to some important conclusions and recommendations on short course pedagogy. Extensive testing procedures can be devised later to evaluate other short courses, offered by other institutions, other instructors and other instructional designs.

Additionally, it may be feasible to utilize information gained from post-testing the students who attend these same courses given in the summer of 1978, again with the same instructor, covering the same material, in the same or similar geographical locations. The instructional design used in the 1978 courses will probably be the same as that projected for two of the 1979 offerings.

Ultimately, growing out of a follow-on study, it may be possible to say something about the comparative effectiveness of short courses vs. after-hours "stretch-out" courses as the best vehicle for the delivery of continuing education in science and engineering. Clearly, such a comparison cannot be a result of the initial study.

Special Capabilities of UCLA

UCLA Extension has what is probably the most highly developed short course program -- particularly in advanced technology for practicing professionals and managers -- in the nation. Approximately 3500 students are reached through 100 individual short courses in a calendar year. Some of our short courses are given through a university consortium arrangement on other campuses across the country. In 1979, as noted earlier, the subject short courses will be offered at UCLA, Toronto and University of Maryland. Although we have not made contact with these institutions on this point, we have good reason to believe that a properly conceived and funded evaluation program in conjunction with these courses would be looked upon favorably by them.

Perhaps the most critically important asset of UCLA for this project, however, is the Center for the Study of Evaluation (CSE). Unique in the country today, CSE was established in 1966 for the purpose of conducting research and development in measurement, methodology and decision-making. With a multidisciplinary staff drawn from the UCLA and other University of California campuses, CSE has worked at all levels of education, from early childhood to professional schools. CSE has, therefore, experience in developing the state-of-the-art designs for evaluation and the instrumentation to support such work.

A key feature of any project is the objective evaluation that is conducted upon its completion by impartial observers. CSE has a particularly rich assembly of resource people in the evaluation field, on whom it can rely for objective appraisals.

Proposed Project Personnel

Alfred C. Ingersoll, Ph.D., P.E., Principal Investigator, is Director of Continuing Education in Engineering and Mathematics, UCLA Extension and Associate Dean, Continuing Education, School of Engineering and Applied Science. Dr. Ingersoll has 32 years of experience in engineering education, the last eight at UCLA in both academic and continuing engineering studies.

Eva Baker, Ed.D., Coprincipal Investigator, is Director of the Center for the Study [illegible] Evaluation at UCLA.

Richard W. Hamming, Ph.D., instructor in the two short courses to be evaluated, is Adjunct Professor of Electrical Engineering, U.S. Naval Postgraduate School, Monterey, California. Dr. Hamming has been anxious to undertake a study of this character for at least two years and pledges his full cooperation.

Merlin Wittrock, Ed.D., consultant in instructional design, is Professor, Graduate School of Education, UCLA.

Tom R. Mincer, Ph.D., and Estelle D. Klingler, project advisers, are Assistant Directors, Continuing Education in Engineering and Mathematics, UCLA Extension. Dr. Mincer manages the Short Course Program and Estelle Klingler is a specialist in adult education, now pursuing her doctorate at UCLA.

Sincerely,

A.C. Ingersoll

A. C. Ingersoll, P.E.
Director, Continuing Education
in Engineering and Mathematics

ACI:jb

Estimate of Budget and Time Requirements

A preliminary estimate of budget comes to $75,000, for the proposed study, to cover the period January 1 through December 31, 1979. The distribution of the estimated budget is approximately as follows:

Subsidy of 300 students in two courses, six offerings, for their participation in testing program, @ $50	$15,000
Consortium support, University of Maryland and University of Toronto	5,000
Supplemental honorarium for instructor, to engage in test program, two course, six offerings, at $500	3,000
Consultant in instructional design	2,000
Preparation of test-item pool in reference domain, two courses, at $3,000	6,000
Printing, administration and evaluation of tests, four per student, 300 students: 1200 tests @ $50	6,000
Principal Investigator	5,500
Coprincipal Investigator	3,000
Secretarial, ½ FTE for one year	5,000
Supplies & Expense, telephones, travel, printing @ $500/month	6,000
Continuing Education Specialist consultants, CEEM, two at $1,000	2,000
Fringe benefits, all categories	3,700
Total direct costs	$62,200
Indirect costs	12,800
Total Estimate	$75,000

APPENDIX 1-B

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

Directorate for Science Education
Division of Science Education
Development and Research

April 27, 1978

Re: Prelim No. 01168

Dr. Alfred C. Ingersoll
Continuing Education in
Engineering and Math
University of California, Los Angeles
405 Hilgard Avenue
Los Angeles, California 90024

Dear Dr. Ingersoll:

I am pleased to report that peer review and program staff consideration of your above-referenced preliminary proposal to the Foundation's program of Continuing Education for Scientists and Engineers leads us to invite submission of a formal proposal.

Enclosed are documents giving reviewer and staff reactions to the activity proposed, and indicating whether (and if so, what) changes in your preliminary plans are suggested.

Please note also the sheet providing information in addition to that contained in the original Proposal Solicitation (SE 78-58) concerning requested Cover Sheet data and budgeted travel costs.

If, after studying these documents, you wish further discussion before preparing the formal proposal, please feel free to call me at 202/282-7900.

Sincerely,

LW Phillips

Lyle W. Phillips
Program Manager

Enclosures

CONTINUING EDUCATION FOR SCIENTISTS AND ENGINEERS
RECOMMENDATION REGARDING FORMAL PROPOSAL SUBMISSION

UCLA	Alfred C. Ingersoll	01168
Institution	Project Director	Prelim. Proposal No.

Summary of Panel Recommendations:

Invite formal 0 Invite with changes 5 Discourage 0

You are urged to consider carefully the comments made by reviewers as indicated on the attached copies of the review forms. Clarify or expand on those areas in the preliminary proposal that reviewers found unclear or inadequate, and give careful thought to making the changes suggested or give your reasons for not following the suggestions. You may find reviewers making contradictory suggestions: it is your responsibility to make it clear which you accept and which you reject, and why.

CESE STAFF RECOMMENDATION

A formal proposal is encouraged. The rationale for the proposal should be made more convincing. What is the likelihood that the study will have an effect on short courses? How? The research design should also be clarified. What instructional methods are to be evaluated?

The budget should be significantly reduced: suggested level, no more than $45,000. Student subsidies do not seem warranted. Why should there be consortium support?

COVER SHEET

APPENDIX 1-B

SEDR/CESE

CONTINUING EDUCATION

FORMAL PROPOSAL FOR [2] STUDY ☐ CONFERENCE WORKSHOP ☐ OTHER

&6

☐ ENGINEERING
☐ SCIENCE
☒ BOTH E & S

1. Descriptive Title of Project: Evaluation of Short Course Method of Instruction
(Maximum: 12 words)
for Practicing Professionals in Engineering

2. Institution or Organization: The Regents of the University of California
Address: City Los Angeles State California Zip Code 90024
Grant to: The Regents of the University of California
(Official name of organization to which grant should be made)

3. Project Director: Alfred C. Ingersoll Social Security No.* 225-28-0517
(One only)
Title and Academic Address
Department: Cont. Educ. in Engrg. and Math, University Extension
City Los Angeles State California Zip Code 90024
Telephone (Include area code): (213) 825-4950 (Office) (213) 454-0730 (Home)

4. Discipline(s) involved in project: Engineering

5. a. Starting date of project: April 1, 1979
b. Proposed duration of complete project: 12 months

6. Total amount of this request from NSF: $48,582.

7. Grant number(s) of other NSF projects for which project director is responsible:
none

8. Type of proposal ☒ New ☐ Renewal of Grant No.

9. Indicate if proposal has been or will be submitted in whole or in part to other possible sponsors, including NSF or other Federal agencies. (Such information will not prejudice review by the Foundation.)
none

10. Alfred C Ingersoll
Signature of proposed Project Director

Signature of Authorizing Officer

June 14, 1978
Date of Submission

Nancy Covey, Contract and Grant Officer
Typed Name & Title of officer authorized to sign for institution or organization

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*Social security numbers are used by the Foundation to monitor and facilitate the processing of numerous proposals, and to maintain award date. The number is solicited pursuant to the general authority of the Foundation under the NSF Act of 1950 as amended. Submission of social security numbers is voluntary and refusal to disclose a social security number will not affect an institution's eligibility for award.

APPENDIX 1-C

NATIONAL SCIENCE FOUNDATION

PROJECT
SUMMARY

NSF AWARD NO.

NAME OF INSTITUTION (NSF DIRECTORY NAME)
The Regents of the University
of California

ADDRESS OF INSTITUTION (INCLUDE BRANCH/CAMPUS & COMPONENT)
405 Hilgard Avenue
Los Angeles, California 90024

PRINCIPAL INVESTIGATOR
Alfred C. Ingersoll

DIVISION (OFFICE) AND DIRECTORATE
Science Education Development & Research

SECTION

PROPOSAL NUMBER

FISCAL YEAR

PROGRAM
Continuing Education

TITLE OF PROJECT
Evaluation of Short Course Method of Instruction for Practicing Professionals in Engineering

SUMMARY OF PROPOSED WORK (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

This proposal, submitted by Continuing Education in Engineering and Mathematics, UCLA Extension, and the UCLA Center for the Study of Evaluation, requests $ 48,582 for a one-year study, commencing April 1, 1979, of the comparative effectiveness of two methodologies used in teaching two UCLA short courses, "Digital Filters," and "Kalman Filtering." Each course will be presented once on the east coast and once on the west coast, in the summer of 1979, utilizing radically different teaching methodologies, viz. (a) lecture/blackboard style, with a linear sequential type of presentation, and (b) extensive use of two overhead projectors so that the student can learn the relationship and organization of a wide array of fact, theory, application and example. Domain referenced pre-tests, post-tests and retention tests at 4 weeks and 4 months will establish the relative effectiveness of the two teaching techniques. Complex statistical analysis of test data will be required to accommodate variations in mathematical and educational background, age and employment of the participant and geographical environment of the course. Results of study will have wide applicability to short courses given anywhere and to after-hours courses and regular college courses.

PROGRAM APPROVAL

DATE

INSTRUCTIONS FOR USE

1. Program Office will complete all items appearing on the first copy, place Proposal Folder copy in the folder; retain Program Suspense copy; and place other copies inside the folder envelope with carbons intact.
2. Division of Grants and Contracts will post award number, amount granted and inclusive project dates on copies 3 through 7 and distribute these copies.

1. PROPOSAL FOLDER

PROJECT SUMMARY

This proposal, submitted jointly by the Department of Continuing Education in Engineering and Mathematics, UCLA Extension and the UCLA Center for the Study of Evaluation, requests funding in the amount of $48,582 for a 12-month study of the relative effectiveness of two methodologies in the delivery of continuing education through the medium of the short course.

The study period extends from April 1, 1979 to March 31, 1980. This rather advanced period is set to accommodate the offerings of two short courses to be given in the summer of 1979, each to be given once at UCLA and once at the University of Maryland. In order to assess learning effectiveness, participants in each course will be given pre-tests and post-tests immediately before and after taking the course, as well as retention tests at intervals of four weeks and four months after completing the course.

This proposal is responsive to items (2) and (6) in the section entitled "Studies" on page 2 of NSF Proposal Solicitation SE 78-58, "Continuing Education for Scientists and Engineers," viz.

> "(2) Studies leading to the generation of validated criteria for measurement of the effectiveness of particular techniques or methods of delivery of continuing education, and
>
> "(6) Investigation of the learning patterns of adults, with particular emphasis on comparison of learning styles (and appropriate teaching styles) of adult scientists and engineers with their undergraduate and graduate-level counterparts."

The continuing education delivery medium or mode under study in this proposed project is the short course, a period of intensive study -- in this case five successive days of "total immersion" through six to seven hours of class presentation each day plus whatever time the student can give to study and review of class notes and reference works -- in which the participant acquires a fairly comprehensive understanding of a relatively recent development in the technology of science and engineering. It will of course be difficult to draw any direct comparisons between how adult scientists and engineers and their undergraduate and graduate-level

counterparts learn such material because the subject matter content of short courses is generally too new to be incorporated into regular-session classes.

The project will engage primarily in a comparative study of two methodologies in the teaching of short courses to employed engineers and scientists. The two teaching methodologies to be studied are:

(a) the "conventional" lecture approach, supported by limited blackboard illustration, in which the lecturer presents the subject material in a linear, sequential fashion, building the theory block upon block, introducing practical examples after the background theory is developed. This approach is sometimes described as "teaching the student how to learn." The student is provided with a copy of the lecture notes.

(b) the "visual analogue" approach in which the lecturer makes almost exclusive use of projection transparencies, utilizing two "Vu-Graph" projectors simultaneously (so as to hold one picture for reference while pursuing detailed elements of the development on the other). In this approach the student is subjected to a wide array of fact, theory, application and example. He learns to understand the ways in which these elements of new knowledge are organized and related to one another. The student is provided with copies of the transparencies (about 12 per hour of presentation will be used).

Educational psychologists theorize that these approaches are not only different in outward appearance; they actually exercise two different parts of the brain (the left side in the linear sequential approach, the right side in the visual analogue approach). It is important to emphasize that when the week's work is done the students from alternate sections of the same course will have received the same theory and the same examples, and they will all have the same reference textbook. Further, when they have completed the final set of retention tests (four months after taking the course) each student will receive copies of the lecture notes or transparencies from the section of the course that he did not take.

The two courses to be studied are:

"Introduction to Digital Filters," Richard W. Hamming, lecturer

"Kalman Filtering," Joseph L. LeMay and William L. Brogan, lecturers

These courses are ideally suited to this study. They are essentially applied mathematics courses and can be taught with equal validity from either approach. The instructors, each of whom has given his course successfully by the lecture method before, are enthusiastic about engaging in the study and committed to giving their best effort in each teaching methodology without preconception as to the outcome. One course will be given on the west coast by lecture/blackboard and on the east coast with projection transparencies, while for the other the methods will be reversed. In every case the audience is recruited nationally and it is not envisioned that there will be significant differences in audience makeup. Nevertheless, each student will be given a background reference questionnaire, establishing his capability in mathematics, as well as a pre-test of items selected randomly from the reference domain of material to be offered in the course. A post-test of similarly selected items is given on completion of the course, as well as four-week and four-month retention tests made up in the same way.

The project will be under the general management of the principal investigator, Dr. Alfred C. Ingersoll, Director of the Department of Continuing Education in Engineering and Mathematics, UCLA Extension. The CEEM department will provide logistic and administrative support and Dr. Tom R. Mincer, Assistant Director, Short Courses, CEEM, will coordinate all contact with the short course instructors. Dr. Eva Baker, Director of the UCLA Center for the Study of Evaluation and co-principal investigator will coordinate the complex task of generating the test instruments and the more complex task of evaluating the results. Dr. Merlin Wittrock, UCLA Professor of Educational Psychology, is consultant to the project in the field of instructional design.

Dr. Ingersoll, Dr. Baker and Dr. Wittrock all hold professorial appointments at UCLA. Dr. Hamming is Adjunct Professor at the Naval Postgraduate School, Dr. LeMay is Head, Advanced Projects Office at the Aerospace Corporation and Dr. Brogan is Professor and Chairman, Department of Electrical Engineering, University of Nebraska.

The results of this study could have substantial significance for the continuing education community. American industry and government spend millions of dollars each year sending scientists, engineers and managers to short courses. Despite the popularity and extensive utilization of the short course mode of continuing education delivery, there is no more than opinion and conjecture as to the most effective way to conduct short courses. Further, there are no hard data (known to these investigators) on learning retention from short course instruction of whatever methodology.

If this project should yield confirming results from both courses that one methodology is clearly superior to the other, it would of course have considerable applicability to other short courses projected for delivery at UCLA and elsewhere. If both courses showed no appreciable difference in effectiveness of the teaching methodologies this would also be significant, if somewhat disappointing. If the courses showed opposite results, or if one showed a superiority and the other showed nothing, then the project results would be inconclusive, an unfortunate but not uncommon outcome of any research project. If the results of the project are conclusive they can be applied with care to other modes of continuing education delivery, e.g., to after-hours courses, and to undergraduate and graduate courses in regular college sessions.

Ultimately it would be hoped to extend this kind of study to a comparison of the short course with the after-hours course extended over 12 to 15 weeks, covering the same material in the same number of contact hours. The great difference in the character of students and learning environment, however, make such a study an exceedingly complex matter, and one which must await a later opportunity.

NARRATIVE

1. Need for the Study

The short course is one of the most highly developed, yet least studied, methods of delivery of continuing education in science and engineering in the United States today. For purposes of this proposal, a short course may be defined to be that mode of continuing education delivery in which a coherent body of subject material is treated in a formal classroom setting, with one or more specialists lecturing to a class of not more than 60 persons, for six to eight hours per day, for a period of 3 to 10 days (most commonly 5 days). The short course usually involves almost no learning reinforcement, evaluation of knowledge learned or skills acquired, and the communication is at a high level of sophistication.

Every year millions of dollars are spent by industry and government agencies in sending their scientists and engineers to short courses. To a considerable extent these are given through university extensions but a growing number of short courses are given by professional societies and entrepreneurial organizations. Fees charged for attendance at short courses are on the order of $100 to $150 per day and commonly the cost to the company sponsoring the attendee is between four and five times this when one counts travel, per diem expenses and replacement of the individual in his employment.

In contrast to the conventional "after-hours" type of continuing education delivery the short course has never involved much evaluation of the student's participation in the course. Conversely there is considerable evaluation of the course itself and of the instructors. Students and instructors alike seem to agree that a conventional examination is not a realistic method of evaluating learning in the short course mode. For one thing there is little or no opportunity for the student to engage in meaningful homework assignments (and to have them corrected and returned during the few days of the course) and most instructors are reluctant to ask students to answer questions or work problems in an examination without prior homework on the subject.

Because the total expense of attending a short course is so high (and it usually runs between three and 20 times the cost of attending an after-hours course covering the same material), the participants have commonly come from the ranks of well established corporate (or government) technical management. With the ever-increasing requirements in industry and government for accountability, the demand for objective evaluation of the short course participant's learning experience is growing rapidly.

There is of course no one best way to teach difficult courses or subjects in college or in continuing education courses for professionals. Different problems and objectives of teaching require different approaches to instruction.

Short, intensive continuing education courses, such as the course "Introduction to Digital Filters" or "Kalman Filtering," as taught by the lecturers of UCLA Extension, are especially appropriate for teaching creative problem-solving techniques, new theories, models, and conceptualizations. The reason, we believe, that short courses are highly appropriate for these problems and objectives is as follows. First, to learn new theories and problem-solving techniques involves the learning of a new organization of information, and a new approach to a familiar field of study or to an old problem. Short, intensive courses are well suited to the teaching of a new synthesis of information. In these courses students are immersed in an intensive and absorbing sequence of instruction in which formerly unrelated ideas are juxtaposed with one another.

The principal objective of this study, as explained later in detail, is to make a comparative evaluation of two radically different methods of teaching adults in a short course: a linear verbalized approach as implemented through lecture/blackboard presentation vs. extensive use of visual analogues and images, implemented by overhead projection ("Vu-Graph").

Although this project will not attempt any comparative study of learning retention from a short course as against an after-hours course covering the same material in several weeks, it will nonetheless be one purpose of this study to ascertain the level of retention of information learned in the two short courses under study, for periods up to four months and perhaps longer.

The results of this study -- both as to evaluation of the short course participant's learning experience and as to the comparative evaluation of these two methods of short course teaching -- will be applicable to short course programs of continuing education given anywhere under conditions similar to those of UCLA Extension. There is nothing inherently peculiar to our method of delivery, selection of participants, or conditions under which a short course is given.

a. Response to Reviewers of Preliminary Proposal:

Two principal themes emerged from the comments of reviewers, (a) that budgetary support of short course participants (students) and consortium institutions was not justified, and (b) that the most desirable study in this arena would be one comparing the instructional effectiveness of the intensive short course mode with that of the after-hours course, covering the same subject material in the same number of class hours stretched over a 12-week academic quarter.

b. Budgetary support of short course participants and consortium institutions

With regard to budgetary support of the student participants, who will be the subjects of a rather extensive schedule of testing, we are planning simply to take the advice of the reviewers (and of NSF) and eliminate this element of the budget. Our current plan is to state in the advance publicity to the two study courses that they are part of an ongoing performance evaluation procedure, the purpose of which is to bring the best possible combination of teaching, course content, and learning facility to the UCLA short course program and to the short course methodology in general.

In the advance registration packet there will be further information on the nature of pre-, post- and retention-testing expected of each participant. It will be explained that their responses to the tests will be used only in statistical studies, and their names will not be released in connection with test scores, nor will their employers or sponsors be given test result information.

In order to avoid the "Hawthorne effect," whereby the course participants would try to excel in learning because they know they are the subjects of an important national study, the instructor will make no references to the study, nor will he suggest that his instructional procedure is anything other than his standard approach. (Indeed one presentation in each study course is the instructor's standard lecturing approach).

Two possible difficulties are envisioned, neither of which appears sufficiently serious to require advance preparations for their eventuality. On the one hand, there may be applicants who wish to take one of the study courses without being subjected to the test procedures. These applicants will receive notification that their registration for the course is being held in abeyance, pending receipt of applications from those willing to take the tests. If there is room in the course, after all willing applicants have been accommodated, the diffident applicants will be welcome. Of course it will be hoped that such individuals will then change their minds and agree to take the tests. On the other hand, there may be participants who start out taking the pretest, and possibly the post-test on completion of the course, but who fail to complete the retention studies (currently contemplated at four weeks and four months). One "carrot" that we plan to use to encourage completion of the tests will be to send each course participant who returns his completed tests a set of the lecture notes or transparencies that he did not get in the course as he took it.

With regard to support for consortium institution(s), this will be reduced to a bare minimum, allowing only for the direct expense of administering the tests (and even these will be done by mail where possible) and providing a student monitor in the classroom. Preliminary contact with Mr. John Lathrop of University of Maryland Engineering Extension assures us of his interest and enthusiasm for the project. He needs only to secure formal approval of their review committee.

c. Comparing short courses with after-hours "stretch-out" courses

As much as we would agree with the desirability of finding a reliable answer to this oft-posed question, we do not think it can be done -- and especially not for the budget envisioned -- in anything more than a superficial way. It would of course be possible to ask the participants at the close of a short course a series of questions relating to how they felt about the course and what they had learned from it, etc., and to ask these same questions of the participants of an after-hours course covering the same material in the same number of class hours. Hopefully, there would be students in both groups who had participated in courses of the other format, and could therefore offer some valid comparative statements.

As attractive as it might seem to pursue such a simplistic approach, for whatever it might be worth, we reject the notion that it could provide any real comparison between these two modes. Any valid comparison between two evaluated entities should involve only one variable. In order to compare short courses with after-hours courses, the one desired variable is the chronological schedule. Concomitant and unavoidable supplementary variables, however, would include (i) the character and qualifications of the student body, (ii) the instructor and his approach to teaching, (iii) the opportunity for the after-hours student to study his notes between sessions and work homework problems, and (iv) factors of environment and fatigue, which are markedly different in the two modes under consideration.

For a number of reasons, short courses command a fee of four or five times that of after-hours courses covering comparable material. This means that the character of participants attending a short course is a great deal different from that of after-hours students. In fact corporate funding of fees for attending these two types of program is generally drawn from two separate budget categories: Educational Assistance and Reimbursement for the after-hours course and Company-Requested Education for the short courses. Clearly, the average short course participant is more highly positioned, and thus more limited in the protracted attention he can give to the subject, than the average after-hours student. Except by very expensive subsidy it would be almost impossible to assemble the same character of students in a short course and a comparable after-hours course.

The same can be said of instructors. Almost without exception, short course instructors are drawn from the top ranks of specialists in the subject field, usually those who have written widely known papers and books, and these individuals are simply notavailable to give a 12-week series of evening courses in Los Angeles (again, without a considerable subsidy).

What the after-hours student lacks in red-carpet environment, company time, and prestigious instructor, he makes up in motivation and hard work, studying between class sessions and working problems, finding applications on his job. He may be fatigued from trying to concentrate after a hard working day, but his goal-directed drive may carry him through to a deeper understanding of the subject material than the short course participant can gain in one week's exposure.

Our own intuition is that the short course is a better medium for teaching conceptual material while the after-hours course is better for giving the student some competence in problem-solving and practical application. It goes almost without saying that the short course is generally oriented toward the more mature professional (commonly one who is managing engineers and scientists) while the after-hours course is designed for younger engineers and scientists, working their way up in their organizations.

Without question, it would indeed be a worthy objective of a future and considerably expanded project to attack a comparative assessment of the short course and the after-hours course as two competing modes of delivering continuing education to practicing professionals. We are convinced, however, that the place to start such a study is in acquiring a better understanding of the effectiveness of different patterns of instruction within a single delivery mode. Such an approach is the essence of this proposal.

As a follow-on project, a comparative study of the sort suggested above could well be undertaken by UCLA Extension. Substantial experience in both the after-hours extended course and the short course modes make this institution an ideal choice for such a study. A proposal will be submitted when appropriate (on invitation).

2. Project Goals

This proposal is responsive to two subgroups under the category of "Studies" in the NSF Proposal Solicitation SE 78-58, viz.

(2) Studies leading to the generation of validated criteria for measurement of the effectiveness of particular techniques or methods of delivery of continuing education, and

(6) Investigation of the learning patterns of adults, with particular emphasis on comparison of learning styles (and appropriate teaching styles) of adult scientists and engineers with their undergraduate and graduate-level counterparts.

The categorical technique of continuing education with which this proposal is concerned is the short course, and the study will concentrate on a comparison of two radically different teaching methods, to accomplish the same educational objectives with the same types of students. One method will be that traditionally utilized in undergraduate engineering and science education, and the method currently used in both of the courses under study -- that of the conventional lecture and blackboard presentation providing a linear verbalization of the material with limited illustration -- while the other method will engage almost exclusive use of visual analogues through overhead projection, using two projectors.

The principal goal of the project will be to determine whether one of these teaching methods is clearly superior to the other. While practically any lecturer in continuing education courses for adult professionals has his own view of which method is the better, there is -- so far as is known here -- no fully credible study demonstrating the superiority of either method.

An adjunct goal of the project will be to attempt a correlation of learning and retention in these two teaching methods with the nature of the material to be learned, i.e.,"learning to learn" (which is envisioned as the objective of the lecture/blackboard approach) vs. gaining an understanding of the organization and arrangement of a wide array of factual information (conveyed in the two-projector approach). Each of the two courses will be constituted of a mix of such information so any conclusion along these lines can be derived only from a substantial analysis of the data. It is immediately apparent that the ideal method for teaching a short course is a mix of the lecture/blackboard and projection techniques. Unless one can learn from a project like this which method is superior to the other, and for what types of information, however, the future instructor planning his short course presentation will be "flying blind" to about the same extent he is today.

A further goal of the project will be to learn something of what is possible in the way of permanent retention (or at least retention over several months) of knowledge learned in a few days of "total immersion" type of instruction. This involves substantial policy implications for industrial training programs, for there is a considerable body of professional opinion in industry today that views a short course as an excellent opportunity to gain a "broad-brush" treatment (but no more than this) of a subject, so as to become conversant in a technical subject without really understanding it. The retention tests to be given at four-week and four-month periods following the courses of this project may indicate quite a different conclusion. It would be hoped, of course, that this study might show sufficient portent of important results that a more comprehensive program of retention testing would become the subject of a later proposal.

Reference has already been made, in the preceding section, to the oft-proposed comparison study that would evaluate continuing education delivery via the short course mode versus the after-hours course spread over several weeks. We have made it clear that while this is not a feasible goal of the current project, it is unquestionably an important goal to be pursued in a later and more extensive project.

3. Activity Plan

(a) Design.

Two UCLA short courses, to be offered in two locations each (UCLA and University of Maryland) in the summer of 1979, will be the subjects of this study on comparative effectiveness of alternate methods of instruction. (a) lecture and blackboard work exclusively, and (b) predominant use of overhead projections, utilizing two projectors. The courses and instructors are:

"Introduction to Digital Filters," Richard W. Hamming

"Kalman Filtering" Joseph L. LeMay and William L. Brogan

These courses are somewhat similar in character. Each is more of a course in applied mathematics than a "how-to-do-it" engineering design or operations course. The courses are ideally suited to this study because, while some short courses must involve a substantial amount of visual-aid material, each of these can be taught well with none or with a great deal. Both courses are part of the current offerings of UCLA Extension (see brochures in Appendix III). Both courses are at present taught by the lecture-blackboard method of presentation.

Each instructor is enthusiastic about participating in this study, with the simple objective of learning how his course may ultimately be improved. Each instructor is prepared to enter the study without preconceived notion as to the outcome, and to give his best effort to each of the two competing methods of instruction. Further, each has presented course material before in the exclusive lecture/blackboard mode, and in the overhead projection mode.

It is appropriate to digress at this point and remark that a great many possibilities for a study of this general character come to mind. In searching for parameters that affect the overall effectiveness or quality of a short course, one can easily assemble a list that would include, in addition to the lecture vs. overhead projection approach contemplated here, such things as (i) inductive vs. deductive approach to presenting the material, (ii) order of presentation, i.e., building up to a summary on the last day or giving an "executive overview" on the first day, followed by detailed presentations in later days, (iii) class format, plenary sessions vs. group sessions for case study discussions, and (iv) schedule format, e.g., five days of the same schedule (8:30 to 4:30) vs. four longer days (same total class hours) with a mid-week day free for reflection and study, or (v) class time devoted almost exclusively to theory, with applications given in handouts for later perusal by students, vs. class time devoted to applications, with background theory given in handouts. The possibilities are endless.

We have been guided in our selection of instructional technique both by the predilection of the instructors and by recognizing certain priorities that short course participants have indicated very clearly that they want: practical examples, new ideas, theory, and design/analysis techniques. Short course participants pay a high fee to enroll in a course and they are much more interested in learning everything they can from the recognized authority than they are in engaging in class discussion (which would rate a higher priority, for example, in conventional college classes).

As much as certain instructors may have some intuitive feeling about the relative effectiveness of straight lecturing (with blackboard for necessary visual presentation of equations, etc.) vs. extensive use of overhead projections or slides, nobody has run a research project on this subject and further, there is no recognized agreement among poeple knowledgeable in this field as to any basic superiority of one approach versus the other.

As conceived by those knowledgeable in the field of educational psychology, the lecture/blackboard approach is a way of leading the student through a linear presentation, building the theory block upon block, with practical examples introduced where appropriate. The student actually gains an appreciation of the thinking or learning process involved as the instructor progresses sequentially through the material. In the overhead projection technique, on the other hand, the student is introduced via visual analogues (e.g., flow charts, etc.) to the relationships among a wide array of facts, theory, and examples. He gains an organizational understanding of the material first, with supporting details taken up as necessary.

Operationally, the study is simple enough: each course will be given once on the west coast and once on the east coast using the alternate instructional methods. There should be no inherent difference between the east- and west-coast audiences because they are both drawn from a nationwide pool no matter where the course is actually offered. In one course the west-coast presentation will utilize lecture/blackboard technique, while the east-coast presentation will utilize the other instructional method (i.e., overhead projection). For the other class, the east/west roles will be reversed. The comprehensive testing procedures, under the direction of the UCLA Center for the Study of Evaluation -- a part of the Graduate School of Education -- should reveal whether or not there is significant difference in these instructional methods, in terms of cognitive learning, affective learning, perceptual learning, retention, and carryover or application to the individual's job situation.

In the lecture/blackboard mode the students will be given a set of lecture notes as well as a background reference textbook. It is important to understand that the textbook will contain all of the information to be conveyed on the overhead projections of the alternate teaching method. In the overhead projection method the instructor will use two projectors so that one slide can be left for reference while the lecturer proceeds through several detailed slides on the other projector. The students will be given copies of the projection transparencies used (about 10 or 12 per hour of instruction) as well as the same textbook given the alternate class. Thus, both sets of students will receive the same overall information, will work to the same course objectives, and will be given the same textbook. The only difference -- and the subject of this study -- will be that one set of students will receive lecture notes (and they will probably take notes of their own from the lecture/blackboard presentations) while the other set will have copies of the transparencies (on which they will doubtless write some of their own notes). On completion of the retention tests each student will receive the lecture notes or copies of transparencies from the alternate mode of the course he took.

To the casual observer the proposed research plan may sound very involved and expensive for a relatively modest outcome in terms of information. In view of the present lack of information on this subject, however, it should be clear that any significant result would be worth the investment of time and money in this project. A "significant result" would be, for example, the situation where both instructors and courses yielded the same outcome, either (i) the lecture method is superior to the use of projection transparencies, or (ii) vice versa, or (iii) there is no significant difference between these instructional methods. Any of these results would, in the view of the investigators, justify the project.

Should it happen that one instructor (and course) yields one of the above results while the other instructor and course yield a different result, then the study would be inconclusive, an unfortunate but not uncommon outcome of research undertaken in any field.

For the educational psychologist there is an added dimension of interest in this study. Dr. Merlin Wittrock, principal consultant to the project in the field of educational psychology, points out relevant current research about information processing strategies that emphasize the importance of using analogues and images to represent abstract concepts. The projection transparencies present images and analogues of the relations among the parts of the theory, while the lecture presents the parts of the theory or model in a linear order. While it is not a direct objective of this study to make a comparative analysis of left and right brain activity and performance, (which is what is supposedly involved in the foregoing analysis), it is surely intriguing to think that the results of the study may be useful to those who are equipped to deal in these concepts.

(b) Testing (Samples)

Upon registration each student will complete a background questionnaire indicating his level of formal education and experience bearing on the subject of the course. He will state specifically his education in and current familiarity with mathematical concepts that will be assumed as tools available to all student participants, and will not be taught in the course. The final analysis of what each student has learned in each course can then be correlated with background level in mathematics in order to remove this as an uncontrolled variable.

It is important to understand that the students in each of the two test courses will have identical course objectives, whether they are in the classes taught by lecture or by transparency projection. Further, they will be given identical pre-, post- and retention-test instruments (currently projected to be at four weeks and four months following the course), four tests in all.

The four tests given each student will be constructed in the same way for each course. The instructor will be asked to identify the principal objectives of the course, probably no more than three or four. For each course objective there will be established the domain of information, attitude, problem-solving ability, etc. that is to be covered in that course during the week.

For each domain there is next established a pool of about 40 test items, individual questions relating to this domain, questions which will be answered during the short course. Special test writers from the Center for the Study of Evaluation will work with the instructors to write these test items. Some may be multiple-choice questions, some may be short answer questions, while others may involve a more lengthy statement. The test items in any one domain pool should be similar to one another in complexity.

The pre-test for all students in one course is derived by drawing about 10 test items at random from each pool for that course. The pre-test would be given before the opening session of the course probably the evening before (or it might better be achieved by mail, before the student arrives in Los Angeles). Although some of the questions may require grading by the instructor, he will not see them until after all sections of the course have been given.

The post-test or exit test will be given the students at the conclusion of the course (probably also by mail). This test will be made up of 10 more test items in each domain, selected at random from the remaining items in the pool.

The four-week and four-month retention tests will be derived in the same way, ultimately utilizing all of the test items developed for each domain. These will of course be administered by mail and it will be important to impress on each student that his performance on the tests is for research purposes only and will not be available to anyone in his organization; thus he is to provide only his own responses to the questions, without reference to his associates, class notes or textbook.

It seems evident that the retention tests must also include some behavioral questions which will tell to what extent the student has had opportunity (or motivation) to study the material he had in the course and/or to apply it to his job situation.

(c) Data Analysis

The Center for the Study of Evaluation will undertake the analysis of the test results from both courses. The ensuing report will comprise the main element of the final project report to the sponsor, NSF.

Data analysis will employ a multi-dimensional repeated measure design, treating the results of each course, except as noted below, as a separate design. (Separate analyses will be necessary because the two courses differ in content and outcome measures will necessarily differ.) An initial step in data analyses will be to test the hypothesis that the four samples included in the study are equivalent, i.e., individuals in course 1/lecture method = those in course 1/audio-visual method = those in course 2/lecture method = those in course 2/audio-visual method. This preliminary analysis will utilize the demographic information, background level in mathematics and pre-test data, with the individual as the unit of analysis. Given that these initial analyses confirm the equivalence hypothesis, we can then generalize our results to the population of individuals who are likely to take such short courses (i.e., assuming, as indicated earlier, that the present sample of short course participants are similar to both past and future participants.) If, on the other hand, preliminary analyses indicate that the samples differ, then covariance models, or other adjustments, will be applied in subsequent analyses in order to adjust for initial differences among groups.

Separate multivariate analyses will be undertaken to determine differences between the audio-visual and lecture methods in each course. Repeated measures will include pre-test, post-test I (i.e., at the end of the course), Post-test II (i.e., four-week retention) and post-test III (four-month retention). Each test occasion will include information measures, problem-solving measures and attitude measures; each type of measure will be treated as a separate dependent measure. Such an analysis will allow us to detect difference between methods at each time period, and at various combinations, and also to examine the interactions among the results of different measures. In addition, if some of the problem-solving and attitudinal questions are the same for both courses, then these results may be analyzed using a single four-cell multivariate design, which will allow us to examine the interactions between course and presentation modes.

(d) Additional Measures of Course Effectiveness

Although the objective testing procedures described above will presumably provide the best measure of overall course effectiveness for the two courses under study, there are other factors worthy of consideration. One of these, of course, is the apparent comprehension of the students in the class as the course progresses through the week. To make some assessment of this factor it is intended that each offering of each course be monitored by a graduate student in educational psychology. He can observe the overall class reaction to the teaching mode, take note of questions and interruptions, etc. In the overhead-projection mode the monitor will note the amount of time that each slide is displayed. Further he will make a tape cassette recording of the entire class proceeding.

4. Schedule of Activities Formal starting date for the project will be April 1, 1979, and termination will be March 31, 1980. This schedule is required because we must have four months after the last course presentation to do the four-month retention testing, and then there must be time for preparation of the final report. Since the short courses are to be given in the summer of 1979, with the last occurring perhaps as late as early September, the retention testing should be completed by mid-January and the report would be completed by March 31.

A good deal of preliminary activity on the part of instructors will take place as soon as the award is made known, for the preparation of the visual transparencies will be complex and prolonged. Nevertheless, the starting date of April 1, 1979 is seen as realistic.

The period of greatest activity will of course be in the summer of 1979, when the four course presentations are actually given. Testing and evaluation will run more or less continuously from early summer, 1979 through January, 1980.

5. Personnel Qualifications The principal investigator, Dr. Alfred C. Ingersoll, is Director of Continuing Education in Engineering and Mathematics, UCLA Extension, and Associate Dean, Continuing Education, as well as Professor in Residence (Engineering Systems) in the School of Engineering and Applied Science. He is active in the Continuing Engineering Studies Division of the American Society for Engineering Education as well as in the educational activities of the American Society of Civil Engineers and the National Society of Professional Engineers.

The co-principal investigator, Dr. Eva L. Baker, is Director, Center for the Study of Evaluation, and Professor and Head of Learning and Instruction in the UCLA Graduate School of Education. She is a member of the Executive Council of the American Psychological Association and a member of the Council for Educational Development and Research as well as a member of the Research Training Committee, American Educational Research Association.

Dr. Merlin Wittrock, consultant, is Professor of Educational Psychology, UCLA Graduate School of Education, and a specialist in the field of instructional design.

Dr. Tom R. Mincer, continuing education specialist consultant, is Assistant Director, Short Courses, Continuing Education in Engineering and Mathematics.

Dr. Richard W. Hamming, coordinator and lecturer in the "Digital Filters" short course, is Adjunct Professor at the Naval Postgraduate School, Monterey, California and an internationally recognized expert in the field of numerical analysis.

Dr. Joseph L. LeMay, Head, Advanced Projects Office, the Aerospace Corporation, coordinator and lecturer in the "Kalman Filtering" short course, has twenty years of technical and managerial experience in navigation, guidance and control systems and seventeen years of college teaching. Dr. LeMay is assisted by Dr. William L. Brogan, Professor and Chairman, Department of Electrical Engineering, University of Nebraska.

Detailed vitae of project personnel are included in Appendix 1-G.

6. Organization and Management Plan

Dr. Alfred Ingersoll, principal investigator, will be responsible for the overall management of this program, and his office will serve as the information and control center for scheduling, fiscal management and reporting. Dr. Ingersoll's office is located in Room 6266, Boelter Hall, the School of Engineering and Applied Science, UCLA. The two west-coast classes to be studied will be conducted in Boelter Hall, which proximity facilitates communication with instructors.

Dr. Tom Mincer, Assistant Director for Short Courses, is responsible for the scheduling and arrangements for the four course offerings at both UCLA and University of Maryland. Contact with students will be coordinated through his office also located in 6266 Boelter Hall.

Dr. Eva Baker, co-principal investigator and Director for the Center of Evaluation and Dr. Merlin Wittrock, consultant in instructional design are located in Moore Hall, the Graduate School of Education, which is adjacent to Boelter Hall. Again, campus locations of key principals provide for excellent working relationships. Dr. Wittrock has already been in contact with instructors regarding instructional design, and Dr. Baker's staff will be working with instructors to develop appropriate tests for the evaluation of their courses. The Center for Evaluation, which has a nation-wide reputation for their expertise in program evaluation will not only provide the measurement instruments but will administer the tests, monitor the classes, develop the data base and provide analysis of the results.

In the management and administration of this program, Dr. Ingersoll will be assisted by a program representative who is a permanent member of his office staff and familiar with not only the Short Course Program but with facilities and services available for the program at UCLA. This program representative has had experience working on grant programs and is aware of the schedules and procedures necessary to administer and maintain financial control. She will be assisting Dr. Ingersoll with the day-to-day administrative details on this program.

7. Dissemination of Project Results

Results of this study, depending on the apparent significance of the outcome (as noted earlier) will become the subject of one or more research papers in appropriate journals and presentations at meetings of appropriate learned and professional societies. The Continuing Engineering Studies Division of the American Society for Engineering Education, which has two national program meetings per year, comes immediately to mind, as does the American Society of Civil Engineers and the National Society of Professional Engineers, both of which organizations are much concerned with continuing education as a legislatively mandated requirement for renewal of professional license.

The ASEE journal, ENGINEERING EDUCATION, is a possible vehicle for a professional paper coming from this project. Another possibility is ENGINEERING ISSUES of ASCE, which concerns itself with matters broadly applicable to the civil engineering profession as a whole. Corresponding journals of the Institute of Electrical and Electronics Engineers, the American Society of Mechanical Engineers and the American Institute of Chemical Engineers, will all be much interested in carrying papers on this especially important project.

Some of the most effective dissemination of results, of course, will occur naturally through the ready use of findings from this project in other short courses. Since UCLA/CEEM sponsors approximately 100 short courses annually one may see how useful results of this project will be carried immediately into action in other short courses.

APPENDIX 1-D

SAMPLE FUNCTIONAL BUDGET (Studies)* SEDR/CESE

Function	Staff Costs	Other Costs	Total Costs
DIRECT COSTS			
A. Project Administration and Management			
1. Coordination of project staff and activities	6,000	1,400 (travel)	7,400
2. Fiscal and other management 3. Preparation of project reports, correspondence and communications	5,000	4,600	9,600
B. Project Activities			
Supplemental honorarium (2 lectr) 1. ~~Analysis of literature, reports and communications~~	2,000		2,000
Consultant, instruct. design	2,000		2,000
2. Preparation of test instrumentation	5,760	730	6,490
3. Field monitoring (UCLA) ~~/testing materials~~	500	50	550
4. Data collection 5. Data reduction and analysis	3,760	1,650	5,410
C. Dissemination Activities (to be achieved approx. summer, 1980 as normal professional activity, no request made at this time for funding)			
1. Preparation of articles, papers, or reports			
2. Conducting workshops or orientation services			
3. Coordinating materials publication and/or distribution			
D. Other University of Maryland (to include monitor)	1,000		1,000
Fringe benefits @ 22% fac. 21% staf	4,385		4,385
INDIRECT COSTS Univ. of Calif. @ 19.1% of total direct costs UCLA Extension @ 6.0% " " " "			9,747
TOTAL			$48,582 TOTAL

*Design of functional budget for conference/workshop or other project is the responsibility of proposed project director.

APPENDIX 1-E

SUMMARY
PROPOSAL BUDGET

FOR NSF USE ONLY	
PROPOSAL NO.	
DURATION (MONTHS)	
PROPOSED	REVISED

ORGANIZATION AND ADDRESS

The Regents of the University of California
405 Hilgard Ave., Los Angeles, CA 90024

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR

Alfred C. Ingersoll

NSF USE	A. SENIOR PERSONNEL (LIST BY NAME; SHOW NUMBERS OF PEOPLE IN BRACKETS; SALARY AMOUNTS MAY BE LISTED ON SEPARATE SCHEDULE) GPM 205.1b	NSF FUNDED MAN MONTHS CAL.	ACAD.	SUMR.	FUNDS REQUESTED BY PROPOSER	FUNDS GRANTED BY NSF (IF DIFFERENT)
	1. P.I./P.D. A. C. Ingersoll	1.6			$ 5,000	$
	2. CO P.I./P.D. Eva Baker (salary distributed				$	$
	3. CO P.I./P.D. over all projects of CSE)				$	$
	4. CO P.I./P.D.				$	$
	5. CO P.I./P.D.				$	$
11115	6. ( ) ← SUBTOTALS A1 - A5 →				$ 5,000	$
	FACULTY AND OTHER SENIOR ASSOCIATES (ATTACH EXTRA SHEET IF NECESSARY)					
	7. Tom R. Mincer	0.4			$ 1,000	$
	8.				$	$
	9.				$	$
	10.				$	$
	11.				$	$
11117	12. ( ) ← SUBTOTALS A7 - A11 →				$ 1,000	$
	B. OTHER PERSONNEL (LIST NUMBERS IN BRACKETS)					
11141	1. ( ) POSTDOCTORAL ASSOCIATES				$	$
11149	2. (3) OTHER PROFESSIONALS in Ctr. Stud. Eval	3			$ 5,760	$
11150	3. (2) GRADUATE STUDENTS at UCLA				$ 500	$
11152	4. ( ) UNDERGRADUATE STUDENTS				$	$
11182	5. (2) SECRETARIAL - CLERICAL in CEEM and CSE				$ 8,760	$
11183	6. ( ) TECHNICAL, SHOP, OTHER				$	$
	TOTAL SALARIES AND WAGES (A+B)				$ 21,020	$
11200	C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				$ 4,385	$
	TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$ 25,405	$
	D. EQUIPMENT (LIST ITEMS AND DOLLAR AMOUNTS FOR EACH ITEM)					
23181	TOTAL EQUIPMENT				$	$
	E. MATERIALS AND SUPPLIES CEEM: 4,600 CSE: 2,430					
32630					$ 7,030	$
	F. DOMESTIC TRAVEL 2 trips to Washington, DC				1,400	
42111					$	$
	G. FOREIGN TRAVEL (LIST DESTINATION AND AMOUNT FOR EACH TRIP; GPM 731)					
42112					$	$

CANCELS NSF FORMS 98, 135, 569 AND 633 EFFECTIVE 10-1-77

SUMMARY PROPOSAL BUDGET

PROPOSAL NO.

52500	H. PUBLICATION COSTS/PAGE CHARGES (not requested at this time)	$	$
62315	I. COMPUTER (ADPE) SERVICES (included in CSE M&S)	$	$
	J. CONSULTANT SERVICES (IDENTIFY CONSULTANTS BY NAME AND AMOUNT; GPM 516) Richard W. Hamming, short course lecturer $1,000 Joseph R. LeMay, " " " 1,000 Merlin Wittrock, specialist in instr. design 2,000	$ 4,000	$
	K. PARTICIPANT SUPPORT COSTS, IF ALLOWED BY PROGRAM GUIDE (ITEMIZE) GPM 518 1. STIPENDS (none requested) $ 2. TRAVEL $ 3. SUBSISTENCE $ 4. OTHER - SPECIFY $		
	5. TOTAL PARTICIPANT COSTS (K1 + K2 + K3 + K4)	$	$
	L. ALL OTHER DIRECT COSTS (List items and dollar amounts. Details of subcontracts, including work statements and budget, should be explained in full in proposal.) $ Consortium cost, to Univ. of Maryland $ 1,000 (to include class monitoring) $ $		
65001	TOTAL OTHER DIRECT COSTS	$ 1,000	$
	M. TOTAL DIRECT COSTS (A THROUGH L)	$ 38,835	$
	N. INDIRECT COSTS (Specify rate(s) and base(s) for on/off campus activity. Where both are involved, identify itemized costs included in on/off campus bases in remarks.) Univ. of California @ 9.1% $ 7,417 UCLA Extension @ 6.0% 2,330		✓
74100	TOTAL INDIRECT COSTS	$ 9,747	$
	O. TOTAL DIRECT AND INDIRECT COSTS (M + N)	$ 48,582	$
74500	P. LESS RESIDUAL FUNDS (If for further support of current project; GPM 252 and 253)	$	$
75000	Q. AMOUNT OF THIS REQUEST (O MINUS P)	$ 48,582	$

REMARKS

"Revision No. 1" below refers to the first revision following the preliminary proposal, which was $75,000

NOTE: SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPM 233). THIS IS REVISION NO. 1

SIGNATURE OF PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR A. C. Ingersoll	DATE OF SIGNATURE 6-9-78	TYPED OR PRINTED NAME AND TITLE
SIGNATURE OF AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	DATE OF SIGNATURE	TYPED OR PRINTED NAME AND TITLE

FOR NSF USE ONLY

INDIRECT COST RATE VERIFICATION			PROGRAM OFFICER APPROVAL
Date Checked	Date of Rate Sheet	Signature	

Grant Number	Amend No.	Institution	Organization	Fund Acct.	Program	Object

	Proposal Number	Dur.	Chg.	Award Date	Proposed Amount	Fund. Dur.

APPENDIX 1-F

OTHER COMMITMENTS OF SENIOR PERSONNEL

Alfred C. Ingersoll, Project Director, is also Project Director for"Energy Leadership" program, sponsored by Department of Energy. This is a one-week program in June, 1978, with project termination in July/August, 1978. No commitment of time has been made for period of proposed project, April 1, 1979 through March 31, 1980.

Eva L. Baker, Co-Principal Investigator, has full-time appointment as Director, Center for the Study of Evaluation. The Center has a considerable number of on-going grants funded by various agencies, and Dr. Baker provides administrative supervision for all of them. Her time is distributed among all CSE grants proportional to the budget of each. The actual work of preparing and evaluating the reference domain test instruments described in this proposal will be achieved by test-writing personnel hired for this grant (or made available to this grant through termination on other activities) but it is not possible to identify them by name at this time.

Merlin C. Wittrock, educational consultant, has no firm plans for the study period beyond his regular UCLA professorship assignment. He believes that he will spend four to eight weeks as a guest professor at the University of Texas in the summer of 1979. It is important to note, however, that his expertise is required in the early phases of this study, when the instructors are preparing their lecture presentations. No conflict whatever is envisioned.

Richard W. Hamming, Joseph L. LeMay and William L. Brogan all hold full-time jobs in other institutions. None is involved in any other grant activity with UCLA.

APPENDIX 1-G

CURRICULUM VITAE

ALFRED C. INGERSOLL, P.E.

Associate Dean for Continuing Education, School of Engineering and Applied Science;
Director, Continuing Education in Engineering and Mathematics, University Extension
University of California, Los Angeles

Since 1950, following his undergraduate and graduate degrees in civil engineering from the University of Wisconsin, Dr. Ingersoll has been on the faculty of the three major engineering schools of Southern California. After serving 10 years in the Department of Civil Engineering at Caltech, he was Dean of the School of Engineering in the University of Southern California from 1960 to 1970, and since 1970 he has been Associate Dean of Engineering and Director of Continuing Education in Engineering and Mathematics, University Extension, UCLA. He is a registered professional engineer (Civil 11985, Calif.

With background in civil engineering, Dean Ingersoll is a Fellow of the American Society of Civil Engineers, a member of its Education Executive Committee, past president of the 2300-member Los Angeles Section. He is past president (1956-58) of Chi Epsilon (civil engineering) Fraternity. In recognition of his contribution to the civil engineering profession, he was named the 1969 recipient of the Edmund Friedman Professional Recognition Award of the ASCE. The Society of Manufacturing Engineers, Region VII, named Dr. Ingersoll "Educator of the Year, 1972." For his interest in and encouragement of women in engineering, Dean Ingersoll was named the 1971 recipient of the Rodney Chipp Award of the Society of Women Engineers. He was named recipient of a 1977 Outstanding Engineer Merit Award by the Institute for the Advancement of Engineering, Los Angeles.

Author of two books (Heat Conduction, with L. R. Ingersoll and O. J. Zobel, University of Wisconsin Press, 1954; Fluid Mechanics, 5th Ed., with R. L. Daugherty, McGraw-Hill, 1954), and more than 130 technical and nontechnical articles, Dean Ingersoll writes a monthly column, "The Engineer and Society" in THE ENGINEER OF CALIFORNIA. Marcel Dekker, Inc. has named Dr. Ingersoll Editor-in-Chief of their forthcoming Civil Engineering Series.

Active in both the California and National Societies of Professional Engineers, Dean Ingersoll serves as Vice President, Western Region, NSPE. He is a past National Director of CSPE/NSPE and past President and Trustee of the NSPE Educational Foundation as well as Vice President of the California Engineering Foundation. CSPE named Dean Ingersoll "Engineering Educator of the Year" in 1974. Dr. Ingersoll served on the Advisory Board of the Air Force Institute of Technology in 1970-73. He also served as the only educator on the Advisory Committee to the State of California Department of Consumer Affairs.

A past Vice President of the American Society for Engineering Education, Dean Ingersoll serves currently as campus activity coordinator at UCLA. At UCLA Dean Ingersoll teaches the course, "The Engineer and Society," where he endeavors to bring to undergraduate engineering students some of the many social, environmental and ethical issues that concern the engineering profession. He is a director of the Birtcher Corporation, manufacturers of electro-surgical equipment, a diplomate of the American Academy of Environmental Engineers, a director of the Technology Transfer Sociey, and a member of the National University Extension Association, IEEE (Power Engineering Society), Tau Beta Pi, Phi Kappa Phi, the Society of Sigma Xi and the Order of the Engineer.

Dean Ingersoll's professional and civic interests have led him to serve on two citizens' committees for rapid transit. He currently serves on the Citizens' Tax Advisory Committee to Los Angeles County Supervisor James A. Hayes. In 1973-74 Dean Ingersoll served on the Board of Visitors, University of Santa Clara School of Engineering and in 1974 he served as adviser to the Idaho State Department of Education in a review of engineering education in Idaho.

Locally, Dean Ingersoll is past President of the Institute for the Advancement of Engineering and past President of its College of Fellows.

VITA April, 1978

EVA L. BAKER

Director, Center for the Study of Evaluation
145 Moore Hall, UCLA, Los Angeles, CA 90024 (213) 825-4711 Soc. Sec. (550-52-6606)

Education: Ed.D (1967), M.A. (1965), A.B. (1963, University of California, Los Angeles

Employment Experience:

1975 to present,	Director, Center for the Study of Evaluation, UCLA
1973 to present,	Professor and Head of Learning and Instruction, UCLA, Teaching and research in teacher preparation, instructional research and development.
1974	Associate Professor, University of Southern California, taught courses in Europe.
1968-1972	Assistant Professor, UCLA
1967-1968	Member of Professional Staff, Southwest Regional Laboratory Los Alamitos, California. Prepared staff development training. Direct responsibility for development and testing of First-Year Communication Skills Project. Responsible for draft designs of programs in art, social sciences, and Second Year Communication Skills.
1967	Assistant Professor, California State College, Long Beach. Taught two courses on teacher preparation.
1965-1967	Peace Corps Instructor, University of California, Los Angeles. Conducted teacher preparation for Peace Corps volunteers.

Selected Current Professional Activities:

Editorial Boards: Audio Visual Communication Review
American educational Research Journal
Human Performance Quarterly
Reviewer - Journal of Educational Psychology

Special Affiliations:
Executive Council - Elected Member at Large - American Psychological Association
Elected Board Member - Council for Educational Development and Research
Elected Member at Large - American Educational Research Association
Research Training Committee - AERA

Joint University of California-California State University Workgroup on Assessment Procedures in Reading and Writing

University of California-System-Wide Evaluation Advisory Group
Directed evaluation of the California Early Childhood Education Program, regularly assists California legislature and State Department of Education concerning its statewide assessment program, reorganization, and related matters.

Publications: A total of 67 publications, mainly in the field of educational testing and evaluation, teacher education and instructional development. Journals include American Educational Research Journal, Journal of Educational Research, Educational Testing Service Journal, etc.

VITA

MERLIN C. WITTROCK
Professor of Educational Psychology, Graduate School of Education
UCLA, Los Angeles, California 90024

Education:

Ph.D.	1957-1960	University of Illinois Major: Educational Psychology Minor: Psychology
M.Ed.	1955-1956	University of Missouri Major: Educational Psychology
B.S.	1949-1953	University of Missouri Major: Biology Minors: Chemistry and Mathematics

Career Appointments:

1967 - present Professor of Education, UCLA; 1964 - 1967 Associate Professor of Education, UCLA; 1960 - 1964 Assistant Professor of Education, UCLA

Special Recognitions:

Fellow, Center for Advanced Study in the Behavioral Sciences, 1967-1968
Fellow, American Psychological Association
Fellow, American Association for the Advancement of Science
Editor-in-Chief, AERA's seven-volume series Readings in Educational Research
Who's Who in America and 13 additional biographical reference works
Chairman, USOE Conference of Educational Research and Development Center Director, 1968-1969
Director, Ford Foundation's Research Project on Improving Instruction, 1965-1971
Director, UCLA Research and Development Center for the Study of Evaluation, also senior author of the proposal for the Center, 1968-1969

Publications:

"The Human Brain," (senior author) Prentice-Hall, 1977, 214 pp. plus approximately 100 additional publications in the field of instructional psychology, generative learning, etc.

Recent Consultant Activities:

U.S. Department of Health, Education and Welfare: The Secretary
U.S. Department of Health, Education and Welfare: Experimental School Programs
U.S. Office of Education: Improvement of Postsecondary Education
Stanford Research Institute, Advisory Committee for Evaluation of Follow-Through Programs
Science Research Associates, Manuscripts
Allyn and Bacon, Reviewer of Manuscripts
Prentice-Hall, Reviewer of Manuscripts
University of Chicago Press
Allyn and Bacon Publishing Company
Brooks-Cole Publishing Company
Wm. C. Brown Company
Burgess Publishing Company
Houghton-Mifflin Company
Little Brown Company
Wadsworth Corporation

VITAE

RICHARD W. HAMMING, Ph.D., Adjunct Professor, U.S. Naval Postgraduate School, Monterey, California. He began large-scale digital computing in 1945 at Los Alamos, calculating atomic bomb designs. He was at Bell Telephone Laboratories from 1946 to 1976 where he continued working in computing, both military and civilian. His main interest over the years has been numerical analysis, and he was attracted to digital filtering from that field. He spent 1960-61 at Stanford, 1970-71 at the University of California, Irvine, and has taught at New York University, City College of New York, Princeton University (Statistics) and Stevens Institute of Technology (Mathematics). He has received the ACM Turing Prize, is a Fellow of IEEE, and is perhaps best known for error correcting codes, a method of numerically integrating differential equations, and a spectral window.

JOSEPH L. LeMAY, The Aerospace Corporation, Los Angeles, California. Ph.D., University of Michigan. Twenty-one years of technical and managerial experience in navigation guidance and control systems with technical disciplines including operations research, modern control theory, stochastic control theory, probability theory and statistical inference, estimation theory and Kalman Filter theory. Seventeen years of teaching: University of Michigan, Loyola University and UCLA. Many technical papers. Member: IEEE, AIAA, six honorary societies.

WILLIAM L. BROGAN, Professor, Department of Electrical Engineering, The University of Nebraska, Lincoln, Nebraska.

TOM R. MINCER, Assistant Director, Short Courses and Conferences, UCLA Extension. Dr. Mincer received his B.S. in Engineering from California State University, Northridge and his M.S. and Ph.D. in Aerospace Engineering from USC. He joined UCLA Extension in 1973 and is responsible for administration of UCLA's national level executive training programs in Engineering, Engineering Management, Mathematics and Science. His background prior to joining UCLA included aerospace industry and university research, consulting and extensive teaching.

UCLA Extension

Continuing Professional Education
Short Course Programs
- Engineering - Management - Mathematics - Science

and the University of Maryland University College,
Conferences and Institutes Division
announce

Digital Filters

July 29-August 3 **at the University of Maryland**
August 19-24 **at UCLA**

Coordinated by **Richard W. Hamming**

Summer 1979
A national university short course consortium

Digital Filters

Intent

For people who wish to learn the elements of this important new field, especially data processing people, numerical analysts, statisticians and mini- and microcomputer users. The course provides a simple introduction that does not depend on an extensive electrical engineering or mathematical background.

Course Content

Digital filter theory is fundamental to modern data processing, signal processing, numerical computation and statistics, but unfortunately the theory arose mainly from the field of analog filtering in electrical engineering and is usually presented as if the student already had several courses in analog filter theory. ***This course makes no such assumptions.*** Instead it develops the necessary material from a basic knowledge in the calculus plus a general knowledge of science. Although some jargon is necessary, the course avoids the unnecessary jargon that comes from various fields of application, and it is mentioned chiefly to acquaint the participants with the words so that they can later read and recognize them in other places.

The course begins with a careful introduction to why the frequency approach is the natural one to use in many situations, goes on to show how the frequency approach illuminates many methods that were based on the polynomial approach. Without spending undue effort on mathematical rigor, the course develops those parts of the theory of Fourier series and integrals that are necessary.

The course develops general methods of designing non-recursive filters, with the emphasis on general, practical methods rather than on special methods that may or may not save a few computer seconds.

Next, the discrete Fourier transform is taken up, along with its fast Fourier transform implementation, and the estimation of power spectra is discussed. Finally, the theory of recursive filter design is examined, again concentrating on general ideas and methods. A brief discussion on nonlinear phenomena, which arise as a result of the practical necessity to quantize signals, is also included.

The course grew out of the realization that mini- and microcomputers are now widely used and that many people are actually doing digital filtering without knowing what they are doing to their signals, or what they might be able to do if they knew the elements of digital filter theory. The annoyance of the jargon that surrounds the field and which makes it almost impenetrable by the outsider caused the course to be created. The text is based on the knowledge of experts, and was filtered through persons who were once outsiders and appreciate the outsider's difficulties.

Prerequisite

Calculus, some differential equations, the elements of statistics and a general scientific knowledge

Textbook

Digital Filters, R.W. Hamming, Prentice-Hall, 1979. (Fee includes textbook.)

University of Maryland
Date: July 29-August 3, 1979
Time: 8:15 am-5 pm
Where: University College, Center of Adult Education, College Park, Maryland
3 CEU

Fee: $500

UCLA Extension
Date: August 19-24, 1979
Time: 8:15 am-5 pm
Where: 6266 Boelter Hall, UCLA
EDP No. E4918R
Course No. Engineering 881.22
3 CEU

Fee: $500

Coordinator and Lecturer

Richard W. Hamming, PhD, Adjunct Professor, U.S. Naval Postgraduate School, Monterey, California. He began large-scale digital computing in 1945 at Los Alamos, calculating atomic bomb designs. He was at Bell Telephone Laboratories from 1946 to 1976 where he continued working in computing, both military and civilian. His main interest over the years has been numerical analysis, and he was attracted to digital filtering from that field. He spent 1960-61 at Stanford, 1970-71 at the University of California, Irvine, and has taught at New York University, City College of New York, Princeton University (Statistics) and Stevens Institute of Technology (Mathematics). He has received the ACM Turing Prize, is a Fellow of IEEE, and is perhaps best known for error correcting codes, a method of numerically integrating differential equations, and a spectral window.

Faculty Representative (UCLA)

Alan N. Willson, Jr., PhD, Professor, Electrical Sciences and Engineering Department, and Assistant Dean, Graduate Studies, School of Engineering and Applied Science, UCLA

Daily Schedule

Sunday, July 29/August 19

Evening

6:00 Registration and background assessment
7:00 Hosted social and dinner
8:30 Lecture
"The Unreasonable Effectiveness of Mathematics"

Monday, July 30/August 20

Morning

Participant background assessment/What is a digital filter, why should we care and how are we going to treat the topic?/special attention to why the frequency approach is the proper one in many situations.

Afternoon

Examples from past experience viewed as digital filters, including smoothing, supplying missing data, differentiating, integrating and filtering.

Tuesday, July 31/August 21

Morning

Introduction to the theory of Fourier series/relation to least squares/Gibbs Phenomenon/Lanczos smoothing (window).

Afternoon

The simple design of non-recursive digital filters/trial and error/Fourier series approach with window/various improvements/filter sharpening.

Wednesday, August 1/ August 22

Morning

Smooth non-recursive filters/Fourier integral.

Afternoon

Kaiser window and optimization of filter design/finite Fourier series and the fast Fourier transform.

Thursday, August 2/August 23

Morning

Design of recursive filters/reasons for them/nature of problems/Butterworth filters/Chebyshev's criterion and Chebyshev's polynomials.

Afternoon

Quantization and roundoff effects.

Friday, August 3/August 24

Morning

Course effectiveness evaluation. Hosted breakfast meeting.

Recursive filter design extended/power spectral estimation and how to choose a design goal.

Afternoon

Comparison of various methods plus review of course/main points, principles for design, some applications to various areas of computing, statistics, filtering, control and economics.

For information regarding technical content of the course, contact the coordinator, Richard W. Hamming at (408) 649-4797.

Coding and Information Theory

July 16-20, 1979 at UCLA only

This course presents the fundamentals of representation, storage and transmission of data. Protection against storage and transmission errors (noise) using error detection and error correcting (including Hamming) codes is developed. Efficiency enhancement through information compressing codes, such as variable length (Huffman) codes, hash codes, predictive run encoding and Markov chains (probabilistic finite state machines) is discussed. The information theory describing the limits obtainable for error protection and efficiency is presented. Practical illustrations (and underlying philosophy) are used throughout the course. The coordinator/lecturer is ***Richard W. Hamming.***

Course fee: $500

For further information, contact the Short Course Program Office, 6266 Boelter Hall, UCLA Extension, Los Angeles, CA 90024 (213) 825-1047.

General Information

Registration fee includes textbook(s) when indicated, course materials or the use of them, and morning/afternoon coffee breaks. It does not include lodging, meals (unless otherwise specified) or parking at UCLA. Enrollment in each course is limited.

Enrollment

UCLA Extension

Early enrollment is advised. Reservations may be made by telephone for those requiring time to obtain authorization. Companies may enroll for a given number of individuals, supplying names later. However, enrollments should be confirmed three weeks in advance of the course starting date. Those desiring to enroll after this should first verify that space is available. Full fee must accompany the application. For reservations and/or registration information, call (213) 825-1295 or 825-3344.

UCLA Extension reserves the right to cancel or reschedule a short course, and to change instructors.

University of Maryland

Advance registration is encouraged. Billing to organizations will be done only on an organizational letter of authorization to bill or organizational purchase order that must accompany the registration form. Make check or money order payable to University of Maryland. Registration will not be considered complete unless payment or billing authorization accompanies the registration form. ***The University reserves the right to cancel and/or amend the course as described herein.*** Cancellation and refund of registration fees, less $10 processing fee, will be made if notice in writing is received five working days prior to the beginning of the course. A full refund will be made should the University cancel the course due to insufficient enrollment. Any notification of cancellation received within five days of the course will receive a 90% refund. No refunds will be authorized after the first day of the course.

Fellowships (UCLA Extension only)

Any full-time facult[illegible]ber or full-time graduate student from an accredited university may apply for a UCLA Extension Short Course Fellowship. This Fellowship, if awarded, pays one-half of the fee. Written applications should be submitted along with verification of full-time status at least three weeks prior to the course.

Continuing Education Unit (CEU)

One CEU is awarded for each 10 contact hours of satisfactory participation in an organized noncredit continuing education program.

Location

UCLA Extension

Registration is conducted at the Short Course Program Office (unless the course is held off campus), located in Room 6266 Boelter Hall on the UCLA campus, from 7:30-8:30 the first morning of the course. At that time you will receive course materials and the location of your classroom.

University of Maryland

The course is held at the University of Maryland University College Center of Adult Education, located west of the College Park Campus at the intersection of Adelphi Road, University Boulevard (MD 193) and Campus Drive in College Park, Maryland. U.S. Route 1, exit 27, south on the Capital Beltway (Interstate 495) provides easy access to University Boulevard.

Airports that serve this area are (in order of convenience to the University): Baltimore-Washington International, Washington National and Dulles International.

Parking

The UCLA campus requires a daily payment of $1 on a space available basis. Parking information and directions may be obtained at any information station located at the entrances to the campus.

Free parking for over 400 cars is available at Maryland's University College Center of Adult Education.

Housing Information

UCLA Extension

There are many hotels close to the UCLA campus. A representative listing of these hotels will be sent to you upon request. Also, a package arrangement is available with a local hotel that provides special services for UCLA Extension Short Course participants.

University of Maryland

The Center of Adult Education is a complete residential facility featuring a coffee shop, dining rooms, catering services and lodging rooms that offer twin beds, private bath, radio, color TV, telephone and individually-controlled heating/air conditioning. Please make your own lodging reservation on the enclosed University of Maryland Lodging Request Form. Daily rates for guest rooms are $24 (double occupancy) and $20 (single occupancy) plus 5% sales tax.

Additional accommodations are available at local motels. Should the Center be unable to honor your lodging request, you will be notified and referred to a nearby motel.

Program Information

For further information contact:

UCLA Extension
Short Course Program Office,
P.O. Box 24902, UCLA Extension,
Los Angeles, CA 90024
(213) 825-3344 or 825-1295.
Western Union: KDU

University of Maryland
Judith Orth, Administrative Coordinator or Susan Coleman, Program Secretary: University of Maryland University College, Conferences and Institutes Division,
University Blvd. at Adelphi Road,
College Park, MD 20742
(301) 454-5237.

Enroll now by mail using form attached. For additional applications, use photocopy or separate sheet giving all information requested on the enrollment form.

Note: Application forms and fees are to be sent to the respective host university.

University of Maryland Lodging Request Form 79 07-19A

Name ____________________

Conference ____________________

Address ____________________

City/State/ZIP ____________________

Arrival ________ am ________ pm Departure ________ am ________ pm

☐ Single—$20 + tax ☐ Double—$24 + tax

Do not include lodging payment with registration fee.

Mail to: Lodging Reservations, University College Center of Adult Education, University Blvd. at Adelphi Road, College Park, MD 20742

Mailing Lists

To delete or correct the name and/or address of this brochure's mailing label, send a copy of the *entire* address panel (including label and any codes stamped on the brochure) to: Mailing Lists, UCLA Extension, P.O. Box 24902, Los Angeles, CA 90024. Changes cannot be made without this information.

The University of Maryland University College is an equal opportunity institution with respect to both education and employment. The policies, programs and activities are in conformance with pertinent federal and state laws and regulations on nondiscrimination regarding race, color, religion, age, national origin, sex and handicap. The Center of Adult Education is accessible to the handicapped. Registrants who are physically handicapped and require special services are requested to identify themselves at the very earliest opportunity by contacting Mrs. Carol Fouts at (301) 454-4712.

The University of California, in compliance with Titles VI and VII of the Civil Rights Act of 1964, Title IX of the Education Amendments of 1972 (45 CFR 86), and Section 503 and 504 of the Rehabilitation Act of 1973, does not discriminate on the basis of race, color, national origin, religion, sex, or handicap in any of its policies, procedures, or practices; nor does the University, in compliance with the Age Discrimination in Employment Act of 1967 and Section 402 of the Vietnam Era Veterans Readjustment Act of 1974, discriminate against any employees or applicants for employment on the basis of their age or because they are disabled veterans or veterans of the Vietnam era. This nondiscrimination policy covers admission, access, and treatment in University programs and activities, and application for and treatment in University employment. In conformance with University policy and pursuant to Executive Orders 11246 and 11375, Section 503 of the Rehabilitation Act of 1973, and Section 402 of the Vietnam Era Veterans Readjustment Act of 1974, the University of California is an affirmative action/equal opportunity employer. Inquiries regarding the University's equal opportunity policies only may be directed to the Assistant Chancellor—Legal Coordinator, 2135 Murphy Hall, UCLA or to the Director of the Office for Civil Rights, Department of Health, Education and Welfare. For information on special services for handicapped students, you may call the Extension academic program department responsible for the course in which you plan to enroll.

Application Form

University of Maryland

Digital Filters
July 29-August 3, 1979
Program Code: 79-07-29A

Name ______________________________

Dept/Agency ______________________________

Home Address ______________________________

City/State/ZIP ______________________________

Business Address ______________________________

City/State/ZIP ______________________________

Business Phone ______________________________

Home Phone ______________________________

Title ______________________________

☐ Check Enclosed
☐ Purchase Order Enclosed
☐ Billing Authorization to Follow
Registration Fee: $500

The following information will be kept confidential and will be used for statistical purposes only. Your Social Security number is used only as a record identification number and will not be disclosed to any third party except on records sent at the student's request, or otherwise pursuant to the Family Education Rights and Privacy Act of 1974.

Birth Date: mo/day/yr ______________________________
Sex: Male ☐ Female ☐
Social Security Number ______________________________
New Student at UMUC ☐

Mail to: Registration Clerk, University of Maryland University College, Conferences and Institutes Division, University Blvd. at Adelphi Road, College Park, MD 20742

Mail Application for Enrollment (UCLA Extension) Summer 1979

Name (First/Middle/Last) ☐ Male ☐ Female
*Social Security No.
Home Address
Birthdate (Mo/Day/Yr)
City/State
ZIP
Area Code/Daytime Phone
Position or Title
Company
Business Address
City/State
ZIP

*By Regental authority, your Social Security number is requested in order to verify your identity for accurate record keeping. Your providing the number is voluntary.

EDP No.	Course Title and Number	Fee
E4918R	**Digital Filters 881.22**	**$500**

☐ CEU Requested
☐ Please send special package housing information
☐ Please send general housing information
☐ Fee either in full or in part is paid or reimbursed by employer
☐ Check enclosed payable to The Regents of the University of California

Charge ________—______—______—______
☐ BankAmericard
☐ Master Charge
☐ VISA

Authorizing Signature ______________ Mo/Yr Expiration Date ______________

Mail to: P.O. Box 24901, Dept. K, UCLA Extension, Los Angeles, CA 90024

UCLA Extension
10995 Le Conte Ave
Los Angeles, CA 90024

Digital Filters
July 29-August 3 at the *University of Maryland*
August 19-24 at *UCLA*
Summer 1979

UCLA GOLDEN YEAR 1979

NOT PRINTED AT STATE EXPENSE
545-79

APPENDIX 1-I

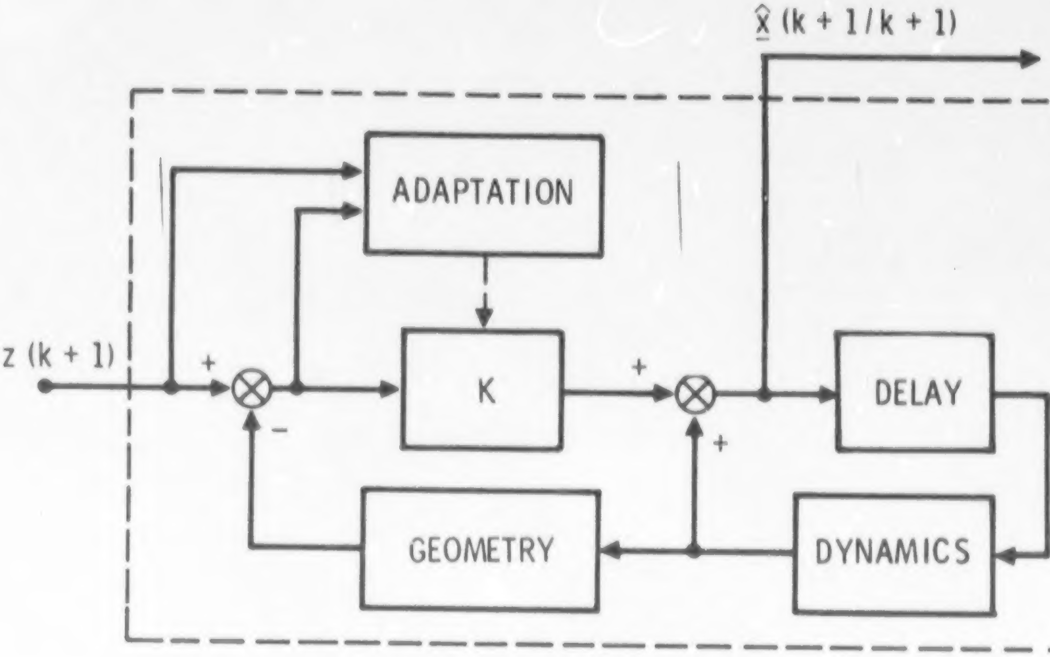
Lifelong Learning

at UCLA Extension

Continuing Professional Education Short Course Program
- Engineering - Management - Mathematics - Science

and the University of Maryland University College,
Conferences and Institutes Division
announce

Kalman Filtering



$\hat{\underline{x}}(k+1/k+1)$
ADAPTATION
z (k + 1)
+
−
K
+
+
DELAY
GEOMETRY
DYNAMICS

August 27-31, 1979 at UCLA
September 10-14, 1979 at the University of Maryland

Coordinated by **Joseph L. LeMay**

A national university short course consortium

Kalman Filtering

Intent

This course is designed for scientists and engineers who want to know what Kalman Filtering is, including its theoretical origin (Kalman Filter derivation); and how to apply Kalman Filtering techniques in problems motivated by physical systems. Pertinent background material from probability theory, random process theory, and estimation theory is included in the course to make the whole presentation self-contained. Since systems-level performance predictions using simulation and/or test data is a large applications area for Kalman Filter techniques, parts of classical statistics and statistical inference, as well as noise-generation techniques for simulations, are included in the course.

Examples of Kalman Filtering applications are included to make the concepts concrete. Simple examples are worked through in detail first, and then large, more complex Kalman Filtering problems are examined. State-space formulations, linear systems theory, and dynamic models required in the developments are included in the course.

The course presents Kalman Filtering as a systems-level methodology of design of estimators for high-order dynamical systems, rather than as an ad hoc filtering technique. In this sense, Kalman Filtering represents an educational discipline containing general foundational principles.

A primary goal of the course is to enable a participant to use the theory and to learn enough about the rigorous derivations to be able to modify, extend or adapt the resulting algorithms as required in particular applications.

Course Content

The course contains a comprehensive set of lectures with typed lecture notes. Major elements of probability theory are presented, including correlation, conditional density functions, n-dimensional gaussian distributions, and properties of conditional gaussian distributions. The theory of random processes is summarized, including definitions for white and Markov processes, and correlation and covariance matrices. Shaping filters are discussed. Major topics from estimation theory include minimum mean square error/unbiased, minimum variance estimators, Maximum Likelihood estimators, least squares and iterative least squares and the Orthogonality Principle.

A step-by-step derivation of the Kalman Filter is presented for the discrete-time case. Results for the continuous-time case and recursive smoothing algorithms are included. A step-by-step development of the Extended Kalman Filter is also presented.

Worked-through examples of Kalman Filtering applications are given, with emphasis on the principles behind the numbers. The causes of divergence in a Kalman Filter are made clear as are effective and practical cures for divergence. Filter "tuning" as an art and as a theory is included in most examples. Physical examples include airplane and satellite navigation, strapped-down inertial navigation, and a pattern recognition problem in the automatic classification of grains.

Alternate filter formulations are presented, including Stabilized Kalman and various square root filters. Computer sizing and timing estimates for the Kalman Filter and alternate formulations are given. The subject of subgroup measurement processing is addressed.

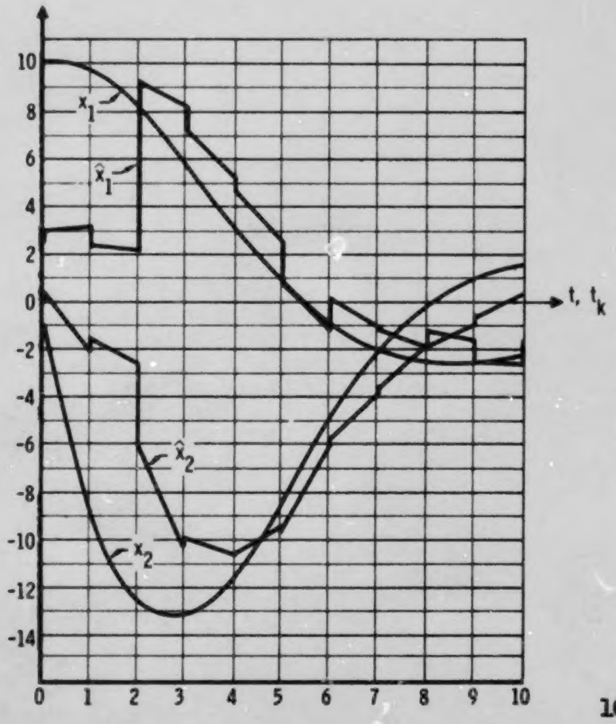
Adaptive estimation is included in the course, and this is the estimation of unknown parameters from measurements as part of a Kalman Filtering process. Different approaches including covariance matching and conditional mean estimation with unknown parameters are covered and motivated by identified, ideal properties of innovations (measurement residuals). Examples of adaptive estimation are included.

Prerequisite

A degree or equivalent experience in engineering or the sciences. Some background in linear algebra and probability theory is recommended.

UCLA Extension
Date: August 27-31, 1979
Time: 8:15 am-5 pm
Where: 6266 Boelter Hall, UCLA
Course No. Engineering 881.38 / 3 CEU
EDP No. E4925Q
Fee: $475, includes lecture notes

University of Maryland
Date: September 10-14, 1979
Time: 8:15 am-5 pm
Where: University College Center of Adult Education, College Park, Maryland
3 CEU
Fee: $500, includes lecture notes



Coordinator and Lecturer

Joseph L. LeMay, The Aerospace Corporation, Los Angeles, California. PhD, University of Michigan. Twenty-two years of technical and managerial experience in navigation, guidance and control systems with technical disciplines including operations research, modern control theory, stochastic control theory, probability theory and statistical inference, estimation theory, and Kalman Filter theory. Seventeen years of teaching: University of Michigan, Loyola University and UCLA; UCLA Extension short course designer, coordinator and lecturer since 1966. Many technical papers. Member: IEEE, AIAA, six honorary societies.

Lecturer
William L. Brogan, Professor, Department of Electrical Engineering, University of Nebraska, Lincoln. Currently on leave, serving as Director of the Systems Science and Operations Research Program at the National Science Foundation, Washington, DC. PhD, UCLA. Eleven years' experience in the aerospace industry in guidance, navigation and control theory. Ten years' academic experience with interests in systems theory, control theory and estimation theory. Consultant to several corporations. Author of the textbook, ***Modern Control Theory,*** Quantum Publishers, Inc., as well as miscellaneous technical papers.

Faculty Representative (UCLA)
Gabor C. Temes, Professor and Chairman, Electrical Sciences and Engineering Department, School of Engineering and Applied Science, UCLA

Daily Schedule

SUNDAY

Evening

6:00 Registration and background assessment
7:00 Hosted social and dinner
8:30 Lecture

Kalman Filtering Introduction and Overview
Kalman Filter block diagram and problem definition, summary model description, predictor/corrector formulation; Kalman Filter features: time domain approach, time-varying processes, finite and growing memory, state-vector formulation for high-order systems; general discussion of divergence in the Kalman Filter, effect of nonlinearities, colored noise, gaussian/linear filter equivalence; identification of required disciplines for Kalman Filter development; goals of the course; familiarization with course notes.

MONDAY

Morning
Probability Theory/Applications
Definitions, fundamental theorems; moments, covariance, correlation; Central Limit Theorem; statistical inference and order statistics; linear algebra manipulations; Monte Carlo and covariance approaches to performance analysis; noise generators for simulations; n-dimensional gaussian distribution; conditional gaussian properties.

Afternoon
Random Process Theory/Applications
Characterization of random processes; ensemble statistics, time statistics; white processes, Markov processes; stationarity, ergodicity; correlation functions, correlation and covariance matrices; dynamic model mean and covariance input-output relations; shaping filters, random sequence generation; introduction of dynamic models to be used in Kalman Filter derivation.

TUESDAY

Morning
Estimation Theory/Applications
Definition of estimation problem; conditional mean estimator, Maximum A Posteriori (MAP) estimator, Maximum Likelihood estimator, minimum mean square error/unbiased, minimum variance estimator; comparison of estimators, role of distribution function assumptions; Orthogonality Principle; least squares and statistical equivalences; a system identification problem; least squares fitting to observations; curve fitting equivalence; other applications of estimation theory.

Afternoon
Kalman Filter Theory
Step-by-step derivation of the discrete-time Kalman Filter; parameters of the filter; separation of covariance/gain computations from filter itself; complete first-order example with some major principles illustrated including filter divergence; correlated measurement and process noises; accounting for deterministic inputs in the Kalman Filter; effects of bias and colored noise; continuous-time Kalman Filter; recursive smoothing algorithms.

WEDNESDAY

Morning
Extended Kalman Filter
Step-by-step derivation of the Extended Kalman Filter; coupling between covariance/gain computations and filter itself; frequency of reference "trajectory" updating; filter tuning; second order example with physical appeal.

Afternoon
Kalman Filtering Applications—I
Step-by-step Kalman Filter design for a second order dynamical system; use of Extended Kalman Filter in satellite navigation with illustration of filter divergence and effective cures; use of satellite navigation system application to illustrate representation of model errors by process noise.

THURSDAY

Morning
Kalman Filtering Applications—II
More Kalman Filtering applications including performance prediction for a wide class of high-altitude satellite navigation systems, a radio/inertial airplane navigation system (a NAVSTAR, GPS application) and automatic classification of grains.

Afternoon
Computational Considerations and Alternate Formulations
Alternate filter formulations including Stabilized Kalman and various square root filters for numerical stability and numerical accuracy; computer sizing and timing estimates for the Kalman Filter and alternate formulations; subgroup measurement processing.

FRIDAY

Morning

Adaptive Estimation

Properties of innovations for a "proper" Kalman Filter; conditional mean estimation with unknown parameters; covariance matching with time statistics of innovations to compute unknown parameters such as the measurement error covariance matrix; examples.

Noon (August and September courses only)
Effectiveness evaluation
Hosted luncheon

For information regarding technical content of the course, contact the coordinator, Joseph L. LeMay at (213) 648-7560.

This course is available to be offered in-plant.

Kalman Filtering Applications Reported by Previous Attendees ***(A Partial List)***

- Satellite Navigation
- Trajectory Reconstruction
- Mixing of Inertial and Radar Navigation Data
- Attitude Determination
- User Algorithms for NAVSTAR Global Positioning System
- Mixing of Loran-C and Heading Data in Ship Navigation
- Tracking Systems (Video, Radar, IR, Laser)
- Inertial System Alignment and Calibration
- Redundant Information Processing
- Positioning Information Nets (JTIDS, OMEGA, LORAN, . . .)
- Detection of Signal Source Location
- Ballistic Missile Trajectory Estimation
- Automatic Classification of Grains

Additional Short Courses in Process of Development

(The following courses will be conducted at UCLA unless otherwise indicated.)

Spread Spectrum Systems and Interference Rejection Techniques
September 17-21, 1979

Modern Radar Technology and Applications
September 24-28, 1979

Advanced Electro-Optical Systems
October 15-19, 1979

Synthetic Array and Imaging Radar
October 22-26, 1979

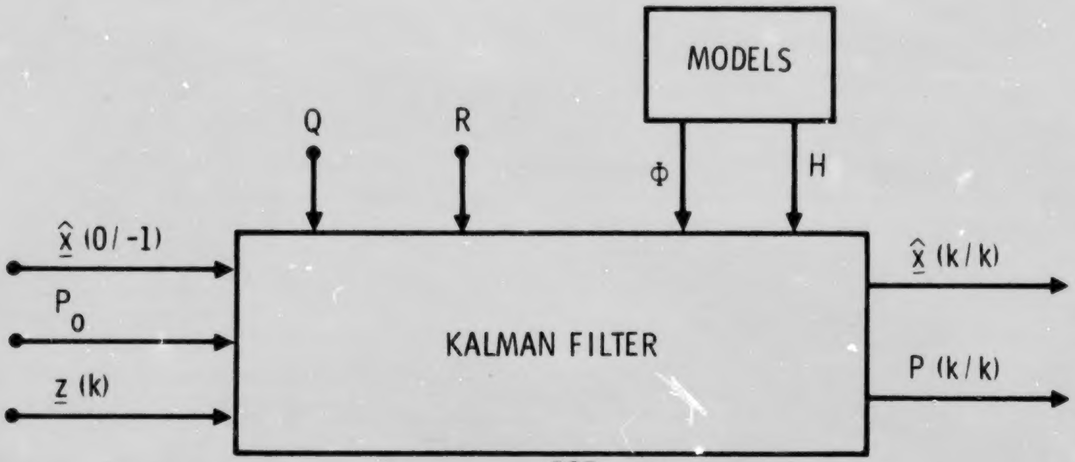
Digital Switching
October 22-26, 1979
University of Maryland

Dynamic Data Analysis for Offshore Structures
November 5-9, 1979

Kalman Filtering II
December 10-14, 1979

Digital Telephony
January 28-February 1, 1980

For further information contact the Short Course Program Office, 6266 Boelter Hall, UCLA Extension,
Los Angeles CA 90024
(213) 825-1047.



General Information

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UCLA Extension

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University of Maryland

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Fellowships (UCLA Extension only)

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Location
UCLA Extension

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UMUC–C&I Division, Quality Inn Lodging Request Form

Name ______________________________

Conference ______________________________

Address ______________________________

City/State/ZIP ______________________________

Arrival ________ am ______ pm Departure ______ am ______ pm

☐ Single $22.50 ☐ Double $30 + tax

Do not include lodging payment with registration fee

Mail to: Quality Inn, 7200 Baltimore Avenue, College Park MD 20740

- -

APPLICATION FORM **University of Maryland**

Kalman Filtering
September 10-14, 1979
Program Code 79-09 10A

Name ______________________________

Dept/Agency ______________________________

Home Address ______________________________

City/State/Zip ______________________________

Business Address ______________________________

City/State/Zip ______________________________

Business Phone ________________ Home Phone ________________

Title ______________________________

☐ Check Enclosed ________________ ☐ Purchase Order Enclosed

☐ Billing Authorization to Follow Registration Fee: $ $500

☐ Please send lodging information

The following information will be kept confidential and will be used for statistical purposes only. Your social security number is used only as a record identification number and will not be disclosed to any third party except on records sent at the student's request, or otherwise pursuant to the Family Education Rights and Privacy Act of 1974.

Birth Date: (Mo) (Day) (Yr) Sex: Male ☐ Female ☐

Social Security Number: ________________ New Student at UMUC ☐

Make check or money order payable to University of Maryland. **Registration will not be considered complete unless payment or billing authorization accompanies this registration form. Send your completed registration form and payment to: Registration Clerk, University of Maryland University College, Conference and Institutes Division, University Blvd. at Adelphi Road, College Park MD 20742.**

University of Maryland
The course is held at the University College Center of Adult Education, located at the intersection of Adelphi Road, University Boulevard and Campus Drive in College Park, Maryland. College Park and the eastern edge of the nearby University of Maryland campus are on U.S. Route 1. Exit 27 south on the Capital Beltway (Interstate 495) provides easy access to U.S. Route 1 and University Boulevard. Airports that serve this area are (in order of convenience to the University) Baltimore-Washington International, Washington National and Dulles International.

Parking
The UCLA campus requires a daily payment of $1 on a space-available basis. Parking information and directions may be obtained at any information station located at the entrances to the campus.

Free parking for over 400 cars is available at Maryland's University College Center of Adult Education.

Housing Information
UCLA Extension
There are many hotels close to the UCLA campus. A representative listing of these hotels will be sent to you upon request. Also, a package arrangement is available with a local hotel that provides special services for UCLA Extension Short Course participants.

University of Maryland
The Center of Adult Education has been given special lodging rates for participants of this course at the Quality Inn, 7200 Baltimore Avenue, College Park, Maryland 20740 (301) 864-5820. Rates are $22.50/single, $30/double plus 10% sales tax. Shuttle service between the Quality Inn and the Center will be provided. A list of additional motels is available upon request.

Enroll now by mail using form attached. For additional applications, use photocopy or separate sheet giving all information requested on the enrollment form. NOTE: Application forms and fees are to be sent to the respective host university.

Mailing Lists
To delete or correct the name and/or address of this brochure's mailing label, send a copy of the ***entire*** address panel (including label and any codes stamped on the brochure) to: Mailing Lists, UCLA Extension, P.O. Box 24902, Los Angeles, CA 90024. Changes cannot be made without this information.

Program Information
For further information contact:

UCLA Extension
Short Course Program Office, P.O. Box 24902, UCLA Extension, Los Angeles, CA 90024, (213) 825-3344 or 825-1295. Western Union KDU

University of Maryland
Judith Orth, Administrative Coordinator or Susan Coleman, Program Secretary; University of Maryland University College, Conferences and Institutes Division, University Blvd at Adelphi Road, College Park, MD 20742, (301) 454-5237.

The University of California, in compliance with Titles VI and VII of the Civil Rights Act of 1964, Title IX of the Education Amendments of 1972 (45 CFR 86), and Sections 503 and 504 of the Rehabilitation Act of 1973, does not discriminate on the basis of race, color, national origin, religion, sex, or handicap in any of its policies, procedures, or practices; nor does the University, in compliance with the Age Discrimination in Employment Act of 1967 and Section 402 of the Vietnam Era Veterans Readjustment Act of 1974, discriminate against any employees or applicants for employment on the basis of their age or because they are disabled veterans or veterans of the Vietnam era. This nondiscrimination policy covers admission, access, and treatment in University programs and activities, and application for and treatment in University employment. In conformance with University policy and pursuant to Executive Orders 11246 and 11375, Section 503 of the Rehabilitation Act of 1973, and Section 402 of the Vietnam Era Veterans Readjustment Act of 1974, the University of California is an affirmative action/equal opportunity employer. Inquiries *regarding the University's equal opportunity policies only* may be directed to the Assistant Chancellor—Legal Coordinator, 2135 Murphy Hall, UCLA or to the Director of the Office for Civil Rights, Department of Health, Education and Welfare. (For information on special services for handicapped students, you may call the Extension academic program department responsible for the course in which you plan to enroll.)

Mail Application for Enrollment **(UCLA Extension)** **Summer 1979**

Name (First/Middle/Last) ☐ Male ☐ Female
*Social Security No.
Home Address
Birthdate (Mo/Day/Yr)
City/State
ZIP
Area Code/Daytime Phone
Position or Title
Company
Business Address
City/State
ZIP

*By Regental authority, your Social Security number is requested in order to verify your identity for accurate record keeping. Your providing the number is voluntary.

EDP No.	Course Title and Number	Fee
E4925Q	Kalman Filtering 881.38	$475

☐ CEU Requested
☐ Please send special package housing information
☐ Please send general housing information
☐ Fee either in full or in part is paid or reimbursed by employer
☐ Check enclosed payable to: The Regents of the University of California

Charge
☐ Bank Americard
☐ Master Charge
☐ VISA

Authorizing Signature
Mo/Yr
Expiration Date

Mail to: P.O. Box 24901, Dept. K, UCLA Extension, Los Angeles, CA 90024

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Kalman Filtering
August 27-31, 1979
at UCLA
September 10-14, 1979
at Maryland

UCLA GOLDEN YEAR 1979

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APPENDIX 1-J

CENTER FOR THE STUDY OF EVALUATION

STATEMENT OF ORGANIZATIONAL CAPABILITIES

The Center for the Study of Evaluation is a University-based research and development center established at UCLA in 1966. For the last ten years the work of the Center has included research, development, training and dissemination activities for the purpose of improving the planning and evaluation of educational and other social action programs. More specifically, these activities involve theory building in the areas of test and measures; development of exportable evaluation procedures and materials in the form of manuals, workshops and kits; and the conduct of special evaluation projects for federal, state, local and University agencies requiring evaluation services. The work of the Center has clarified the ways in which systematic consideration of evaluation issues can be helpful in the planning, conduct and improvement of many kinds of programs.

Currently the Center is organized into four programs: the Bilingual Evaluation Program, the Evaluation Technologies Program, the Special Evaluation Studies Program, and the Field Service Program. Projects within each of the last three programs have direct relevance to the current proposal. For example, within the Evaluation Technologies Program the Center has produced three consumer-oriented test evaluation books which catalogue commercially available norm-referenced tests and is currently producing a fourth for criterion-referenced tests. In the course of this work the Center staff have collected and catalogued all available assessment diagnostic and prognostic instruments for elementary and secondary school students. The secondary school test book alone includes 1167 tests with 5400 subscales. These tests were categorized as to their objectives, content and audience and then evaluated in accordance with carefully described criteria.

Although the test evaluation books have been well received by administrators without technical expertise in evaluation and by educational evaluators and psychometricians the Center is currently conducting a large-scale survey to update the format and design for its prospective publication.

Center staff in both the Special Evaluation Studies Program and the Field Service Program have extensive experience in consulting with or training others to do needs assessment, program planning, formative and summative evaluation for their own programs. These programs range in size and content. For example, Center staff have been involved in a several months' evaluation of a small mental health training project as well as in a year-long evaluation of the Early Childhood Education Program for the State of California. Center staff are experienced in all aspects of evaluation, i.e., the setting up of evaluation designs, the construction and validation of data collection instruments, the reduction of data, computer programming and data analysis and report writing.

The Center has close ties with the Graduate School of Education and with other campus organizations. It has more than 25 faculty affiliates who supplement the talents and expertise of the approximately 70 members of its permanent staff. Eva Baker, an Associate Professor in the Graduate School of Education with professional interest in formative evaluation, product development and teacher education is currently the Director of the Center.

Adrianne Bank who has been with the Center for more than three years is Associate Director. Her Ph.D. is in the area of instructional product development and her interests include career education, teacher training and organizational development in addition to evaluation. She has directed development of the Elementary School Program Planning Kit and the Secondary School Needs Assessment Kit. In this capacity she has supervised the formulation, development, try-out and revision activities of the staffs of both Kits. She has been concerned with the graphic design and production of the Kits as well as with the marketing and dissemination strategies associated with their publication. Prior to her employment at CSE Dr. Bank was the coordinator of the League of Cooperating Schools for the Institute for the Development of Educational Activities (I/D/E/A). In this capacity she planned and supervised the conduct of conferences, workshops, seminars and newsletters as a way of facilitating the exchange of ideas and information among teachers. Avocationally she has helped to establish several women's groups. She has been a consultant to these and other organizations in curriculum development, program planning and evaluation.

APPENDIX 2

TEST INSTRUMENTS

DF - Digital Filters

KF - Kalman Filtering

- 1: Demographic Identification and Pretest
- 2: Posttest
- 3: Five-Week Follow-Up Questionnaire
- 4: Four-Month Follow-Up Questionnaire

DF-1

ID (7 digits) ____________

SHORT COURSE PARTICIPANT PRETEST

This measure will be used solely for the purpose of assessing short course effectiveness: Student responses will be kept strictly confidential.

I. Background Information

1. What is your educational background?

Degree	Institution	Major/Specialization	Year

2. Work assignment/Current job responsibility

__ Industry
__ Government
__ Education
__ Private Practioner
__ Other, please specify
____

__ Technical/design
    __ Research
    __ Management
    __ Operations
    __ Sales

__ Management
__ Education
__ Sales
__ Operation
__ Other, please specify
____

3. Why are you taking this course? What are your objectives?

II. Acquaintance With Background And Course Related Concepts

Read each of the following questions and circle the number which represents your belief about your ability to answer the question. The first question asks for vague knowledge of the concept. The second question asks for specific knowledge. The third question asks about a specific case.

		No	Uncertain	Yes
1. Digital filter	Do you know what a digital filter is?	1	2	3
	Can you accurately define a digital filter?	1	2	3
	Can you write the formula for a digital filter?	1	2	3
2. Statistics	Have you had some statistics?	1	2	3
	Are you familiar with the concepts distribution, mean, and variance?	1	2	3
	Can you find the variance for uniform roundoff?	1	2	3
3. Eigenfunction	Do you know what an eigenfunction is?	1	2	3
	Do you know why eigenfunctions are important?	1	2	3
	Do you know the eigenfunctions of linear systems?	1	2	3
4. Aliasing	Do you know what aliasing is?	1	2	3
	Do you know why aliasing is important in digital filters?	1	2	3
	Can you prove by trigonometry that aliasing must occur under sampling at equally spaced intervals?	1	2	3
5. Principle of least squares	Are you acquainted with the principle of least squares?	1	2	3
	Can you state the principle of least squares?	1	2	3

		No	Uncertain	Yes
	Can you fit a straight line to the data y(-2), y(-1), y(0), y(1), and y(2) using least squares principle?	1	2	3
6. Transfer function	Do you know what a transfer function is?	1	2	3
	Can you describe how to find a transfer function of a digital filter?	1	2	3
	Can you give the transfer function of the formula $y_n=\frac{-3x_{n-2}+12x_{n-1}+17x_n+12x_{n+1}-3x_{n+2}}{35}$? where the data are $\{x_n\}$?	1	2	3
7. Digital filter	Do you know what recursive and nonrecursive filters are?	1	2	3
	Can you define a recursive filter?	1	2	3
	Do you know why integration must be a recursive filter?	1	2	3
8. Finite differences	Do you know much about finite differences?	1	2	3
	Can you write the difference table of the squares of the first five integers?	1	2	3
	Can you compute the transfer function of the difference operator?	1	2	3
9. Orthogonality	Do you know why orthogonality is an important topic?	1	2	3
	Can you define what is meant by two functions being orthogonal?	1	2	3

		No	Uncertain	Yes
	Can you prove that sin mx and cos nx are orthogonal over the interval 0 to π?	1	2	3
10. Fourier series	Are Fourier series and least squares related?	1	2	3
	Can you give the relationship between least squares and Fourier series?	1	2	3
	Do you know what Bessel's inequality is?	1	2	3
11. Gibb's phenomenon	Have you heard of the Gibb's phenomenon?	1	2	3
	Do you know what the Gibb's phenomenon is?	1	2	3
	Do you know why the Gibb's phenomenon occurs at points of discontinuity?	1	2	3
12. e^{ix}	Are you familiar with the function e^{ix}?	1	2	3
	Do you know Euler's identity for e^{ix}?	1	2	3
	Can you prove that the functions e^{imx} are orthogonal over 0 to 2π?	1	2	3
13. Convolution	Do you know what a convolution is?	1	2	3
	Do you know the convolution theorems?	1	2	3
	Can you state the two convolution theorems for the Fourier series?	1	2	3
14. Windows	Have you heard of windows in the Fourier series theory?	1	2	3
	Do you know what a window is?	1	2	3
	Can you describe the Lanczos' window?	1	2	3

		No	Uncertain	Yes
15. Digital filters	Can you design a digital filter?	1	2	3
	Do you know what a low pass filter is?	1	2	3
	Can you compute the coefficients of a low pass filter that passes the lower half of the Nyquist interval?	1	2	3
16. Differentiation	Do you know if the process of differentiating data is a digital filter?	1	2	3
	Do you know why numerical differentiation is difficult?	1	2	3
	Do you know what the transfer function of a differentiator is?	1	2	3
17. Fourier Integral	Do you know anything about the Fourier integral?	1	2	3
	Do you know how Fourier integrals are related to Fourier series?	1	2	3
	Can you give the two formulas for the Fourier integral?	1	2	3
18. Sampling theorem	Have you heard of the sampling theorem?	1	2	3
	Can you define the sampling theorem?	1	2	3
	Can you write the formula and conditions on the sampling theorem?	1	2	3
19. Band limited functions	Are you acquainted with the concept of band limited functions?	1	2	3
	Can you define a band limited function?	1	2	3
	Do you know what the importance of band limited functions is?	1	2	3

		No	Uncertain	Yes
20. Sample size	Are you acquainted with the problem of sample size?	1	2	3
	Do you know what the effect of a finite sample is on statistics?	1	2	3
	Do you know what the window is that corresponds to taking a finite sample?	1	2	3
21. Fast Fourier transform	Have you heard of the Fast Fourier Transform?	1	2	3
	Can you define the Fast Fourier Transform?	1	2	3
	Do you know if the Fast Fourier transform differs from the finite Fourier transform?	1	2	3
22. Finite Fourier series	Are you familiar with the finite Fourier series?	1	2	3
	Do you know about the orthogonality of the Fourier functions over a discrete set of points?	1	2	3
	Do you know how to get a finite Fourier expansion?	1	2	3
23. Recursive filter	Have you ever used a recursive filter?	1	2	3
	Can you define a recursive filter?	1	2	3
	Do you believe you could design a recursive filter with the aid of the textbook examples?	1	2	3
24. Butterworth filter	Have you heard of Butterworth filters?	1	2	3
	Can you define a Butterworth filter?	1	2	3
	Can you design Butterworth filters?	1	2	3

		No	Uncertain	Yes
25. Chebyshev criterion	Have you ever heard of the Chebyshev criterion?	1	2	3
	Can you define the Chebyshev criterion?	1	2	3
	Do you know what a Chebyshev filter is?	1	2	3

III. Specific Background Information

Answer the following ten questions as completely as you can within the 45 minutes allotted for the pretest. If you cannot answer a question go on to the next question.

1. Write out the formula for a digital filter.

2. Find the variance of uniform roundoff.

3. What are the eigenfunctions of a linear system?

4. Prove by trigonometry that aliasing must occur under sampling at equally spaced samples.

5. Fit a straight line to the data y(-2), y(-1), y(0), x(1), and y(2) using the least squares principle.

6. Give the transfer function of the formula

$$y_n = \frac{-3x_{n-2}+12x_{n-1}+17x_n+12x_{n+1}-3x_{n+2}}{35} \ ?$$

where the data are $\{x_n\}$?

7. Why must integration be a recursive filter?

8. Prove that sin mx and cos nx are orthogonal over the interval 0 to 2π.

9. What is Bessel's inequality?

10. Why does the Gibb's phenomenon occur at points of discontinuity?

ID (7 digits) ____________________

SHORT COURSE PARTICIPANT POSTTEST

This measure will be used solely for the purpose of assessing short course effectiveness: Student responses will be kept strictly confidential.

I. Course Evaluation

1. Clarity of presentation
   - a. Excellent
   - b. Good
   - c. Satisfactory
   - d. Poor
   - e. Unsatisfactory

2. Continuity and order of the presentation
   - a. Excellent
   - b. Good
   - c. Satisfactory
   - d. Poor
   - e. Unsatisfactory

3. Speed of delivery
   - a. Much too fast
   - b. A little too fast
   - c. Just right
   - d. A little too slow
   - e. Much too slow

4. Presentation of:

	unsatisfactory	poor	satisfactory	good	excellent
a. Background material	1	2	3	4	5
b. Theory development	1	2	3	4	5
c. Examples	1	2	3	4	5
d. Applications	1	2	3	4	5
e. Procedures	1	2	3	4	5

5. Ability to hold your attention and interest

   a. Excellent
   b. Good
   c. Satisfactory
   d. Poor
   e. Unsatisfactory

6. Quality of visual presentation.

   a. Excellent
   b. Good
   c. Satisfactory
   d. Poor
   e. Unsatisfactory

7. Contribution of visual presentation to your understanding.

   a. Excellent
   b. Good
   c. Satisfactory
   d. Poor
   e. Unsatisfactory

8. Did the course provide adequate preparation so that you could use digital filters in your work?

   a. Excellent
   b. Good
   c. Satisfactory
   d. Poor
   e. Unsatisfactory

9. Additional Comments. Please comment on any specific aspects of the presentation which influenced the effectiveness of the course.

II. Acquaintance With Background And Course Related Concepts

Read each of the following questions and circle the number which represents your belief about your ability to answer the question. The first question asks for vague knowledge of the concept. The second question asks for specific knowledge. The third question asks about a specific case.

		No	Uncertain	Yes
1. Digital filter	Do you know what a digital filter is?	1	2	3
	Can you accurately define a digital filter?	1	2	3
	Can you write the formula for a digital filter?	1	2	3
2. Statistics	Have you had some statistics?	1	2	3
	Are you familiar with the concepts distribution, mean, and variance?	1	2	3
	Can you find the variance for uniform roundoff?	1	2	3
3. Eigenfunction	Do you know what an eigenfunction is?	1	2	3
	Do you know why eigenfunction are important?	1	2	3
	Do you know the eigenfunctions of linear systems?	1	2	3
4. Aliasing	Do you know what aliasing is?	1	2	3
	Do you know why aliasing is important in digital filters?	1	2	3
	Can you prove by trigonometry that aliasing must occur under sampling at equally spaced intervals?	1	2	3
5. Principle of	Are you acquainted with the principle of least squares?	1	2	3
	Can you state the principle of least squares?	1	2	3

		No	Uncertain	Yes
	Can you fit a straight line to the data $y(-2)$, $y(-1)$, $y(0)$, $y(1)$, and $y(2)$ using least squares principle?	1	2	3
6. Transfer function	Do you know what a transfer function is?	1	2	3
	Can you describe how to find a transfer function of a digital filter?	1	2	3
	Can you give the transfer function of a digital filter?	1	2	3
	Can you give the transfer function of the formula $y_n = \frac{-3x_{n-2}+12x_{n-1}+17x_n+12x_{n+1}-3x_{n+2}}{35}$? where the data are $\{x_n\}$?	1	2	3
7. Digital filter	Do you know what recursive and nonrecursive filters are?	1	2	3
	Can you define a recursive filter?	1	2	3
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8. Finite differences	Do you know much about finite differences?	1	2	3
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9. Orthogonality	Do you know why orthogonality is an important topic?	1	2	3
	Can you define what is meant by two functions being orthogonal?	1	2	3

		No	Uncertain	Yes
	Can you prove that sin mx and cos nx are orthogonal over the interval 0 to π?	1	2	3
10. Fourier series	Are Fourier series and least squares related?	1	2	3
	Can you give the relationship between least squares and Fourier series?	1	2	3
	Do you know what Bessel's inequality is?	1	2	3
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	Do you know what the Gibb's phenomenon is?	1	2	3
	Do you know why the Gibb's phenomenon occurs at points of discontinuity?	1	2	3
12. e^{ix}	Are you familiar with the function e^{ix}?	1	2	3
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	Do you know what a window is?	1	2	3
	Can you describe the Lanczos' window?			

		No	Uncertain	Yes
15. Digital filters	Can you design a digital filter?	1	2	3
	Do you know what a low pass filter is?	1	2	3
	Can you compute the coefficients of a low pass filter that passes the lower half of the Nyquist interval?	1	2	3
16. Differentiation	Do you know if the process of differentiating data is a digital filter?	1	2	3
	Do you know why numerical differentiation is difficult?	1	2	3
	Do you know what the transfer function of a differentiator is?	1	2	3
17. Fourier Integral	Do you know anything about the Fourier integral?	1	2	3
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	Can you write the formula and conditions on the sampling theorem?	1	2	3
19. Band limited functions	Are you acquainted with the concept of band limited functions?	1	2	3
	Can you define a band limited function?	1	2	3
	Do you know what the importance of band limited functions is?	1	2	3

		No	Uncertain	Yes
20. Sample size	Are you acquainted with the problem of sample size?	1	2	3
	Do you know what the effect of a finite sample is on statistics?	1	2	3
	Do you know what the window is that corresponds to taking a finite sample?	1	2	3
21. Fast Fourier transform	Have you heard of the Fast Fourier Transform?	1	2	3
	Can you define the Fast Fourier Transform?	1	2	3
	Do you know if the Fast Fourier transform differs from the finite Fourier transform?	1	2	3
22. Finite Fourier series	Are you familiar with the finite Fourier series?	1	2	3
	Do you know about the orthogonality of the Fourier functions over a discrete set of points?	1	2	3
	Do you know how to get a finite Fourier expansion?	1	2	3
23. Recursive filter	Have you ever used a recursive filter?	1	2	3
	Can you define a recursive filter?	1	2	3
	Do you believe you could design a recursive filter with the aid of the textbook examples?	1	2	3
24. Butterworth filter	Have you heard of Butterworth filters?	1	2	3
	Can you define a Butterworth filter?	1	2	3
	Can you design Butterworth filters?	1	2	3

		No	Uncertain	Yes
25. Chebyshev criterion	Have you ever heard of the Chebyshev criterion?	1	2	3
	Can you define the Chebyshev criterion?	1	2	3
	Do you know what a Chebyshev filter is?	1	2	3

III. Specific Course Related Concepts

Answer the following ten questions as completely as you can within the 45 minutes allotted for the posttest. If you cannot answer a question go on to the next question.

1. Prove that the functions $\{e^{imx}\}$ are orthogonal over 0 to 2π.

2. State the two convolution theorems for the Fourier series.

3. Describe the Lanczos' window.

4. Compute the coefficients of a low pass filter that passes half of the Nyquist interval.

5. Give the two formulas for the Fourier integral.

6. Write the fomula and conditions on the sampling theorem.

7. What is the window that corresponds to taking a finite sample?

8. How do you get a finite Fourier expansion?

9. What is a recursive filter?

10. What is a Chebyshev filter?

DF-3

UNIVERSITY OF CALIFORNIA, LOS ANGELES

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UNIVERSITY EXTENSION
Continuing Education in Engineering and Mathematics

6266 Boelter Hall, UCLA
Los Angeles, California 90024

August 31, 1979

Dear Participant in "Digital Filters" Short Course:

It is now just four weeks since you completed our Digital Filters short course, given at the University of Maryland, July 29 to August 4, 1979. As you will recall, we requested your cooperation in a study we have under way on the effectiveness of the short course learning mode. This is the first of two follow-up communications you will receive from us. The second will come along in another three months.

Please complete the attached questionnaire and return to us in the enclosed reply envelope.

It is important that you spend no more than 45 minutes on the questions and further, that you do not consult reference materials or others. Of course this means also that you should not "bone up" on the subject before you open the questionnaire.

You already know, of course, that your response is totally confidential, since we have only your 7-digit identification number to relate to your earlier responses. If you have forgotten the number you put on your previous papers, please write or call me and hopefully we can reconstruct your "statistical identity."

At the conclusion of the project you will receive an abstract of the study.

On behalf of UCLA Extension and the University of Maryland Center of Continuing Education, I wish again to express appreciation for your cooperation. Whatever the outcome of the study it will surely assist us in improving the effectiveness of future short courses.

Please call me (collect if you wish) at (213) 825-4950 if you have any questions. I do look forward to seeing you again in a UCLA short course.

Sincerely,

A. C. Ingersoll

A. C. Ingersoll, P.E.
Director

ACI:jb

Attachment

DF-3

ID (7 digits)______________

SHORT COURSE FOLLOW-UP QUESTIONNAIRE 1

This measure will be used solely for the purpose of assessing short course effectiveness: Student responses will be kept strictly confidential.

I. Course Evaluation

1. Please check the objective which most closely identifies the purpose you had in coming to this course, at the time you enrolled. If more than one item applies, please assign priority, e.t., 1, 2, 3, etc.

2. Circle the number indicating how well the short course satisfied each of the objectives you checked.

		excellent	good	satisfactory	poor	unsatisfactory
____	To get an introduction to the theory of digital filtering.	a	b	c	d	e
____	To get a review of the theory of digital filtering.	a	b	c	d	e
____	to learn applications and applicability of digital filtering.	a	b	c	d	e
____	To learn the language (i.e., a kind of "appreciation" course about digital filters) in order to communicate with others engaged in digital filtering.	a	b	c	d	e
____	To gain an overview in preparation for possible future involvement in digital filtering.	a	b	c	d	e
____	To be able to teach this subject in my organization.	a	b	c	d	e
____	Other (please specify)________________	a	b	c	d	e

3. How much time did you spend studying outside of class during the course?

   a. none
   b. 1-4 hours
   c. 5-8 hours
   d. more than 8 hours

4. How much time have you spent studying the text or class notes since completing the course?

   a. none
   b. 1-4 hours
   c. 5-8 hours
   d. more than 8 hours

5. Have you applied the theory and procedures you learned in the short course in your work?

   a. yes
   b. no

6. How do you rate the digital filters short course at this time?

   a. excellent
   b. good
   c. satisfactory
   d. poor
   e. unsatisfactory

II. Acquaintance With Background And Course Related Concepts

Read each of the following questions and circle the number which represents your belief about your ability to answer the question. The first question asks for vague knowledge of the concept. The second question asks for specific knowledge. The third question asks about a specific case.

		No	Uncertain	Yes
1. Digital filter	Do you know what a digital filter is?	1	2	3
	Can you accurately define a digital filter?	1	2	3
	Can you write the formula for a digital filter?	1	2	3
2. Statistics	Have you had some statistics?	1	2	3
	Are you familiar with the concepts distribution, mean, and variance?	1	2	3
	Can you find the variance for uniform roundoff?	1	2	3
3. Eigenfunction	Do you know what an eigenfunction is?	1	2	3
	Do you know why eigenfunctions are important?	1	2	3
	Do you know the eigenfunctions of linear systems?	1	2	3
4. Aliasing	Do you know what aliasing is?	1	2	3
	Do you know why aliasing is important in digital filters?	1	2	3
	Can you prove by trigonometry that aliasing must occur under sampling at equally spaced intervals?	1	2	3
5. Principle of	Are you acquainted with the principle of least squares?	1	2	3
	Can you state the principle of least squares?	1	2	3

		No	Uncertain	Yes
	Can you fit a straight line to the data y(-2), y(-1), y(0), y(1), and y(2) using least squares principle?	1	2	3
6. Transfer function	Do you know what a transfer function is?	1	2	3
	Can you describe how to find a transfer function of a digital filter?	1	2	3
	Can you give the transfer function of the formula $y_n = \frac{-3x_{n-2}+12x_{n-1}+17x_n+12x_{n+1}-3x_{n+2}}{35}$? where the data are $\{x_n\}$?	1	2	3
7. Digital filter	Do you know what recursive and nonrecursive filters are?	1	2	3
	Can you define a recursive filter?	1	2	3
	Do you know why integration must be a recursive filter?	1	2	3
8. Finite differences	Do you know much about finite differences?	1	2	3
	Can you write the difference table of the squares of the first five integers?	1	2	3
	Can you compute the transfer function of the difference operator?	1	2	3
9. Orthogonality	Do you know why orthogonality is an important topic?	1	2	3
	Can you define what is meant by two functions being orthogonal?	1	2	3

		No	Uncertain	Yes
	Can you prove that sin mx and cos nx are orthogonal over the interval 0 to π?	1	2	3
10. Fourier series	Are Fourier series and least squares related?	1	2	3
	Can you give the relationship between least squares and Fourier series?	1	2	3
	Do you know what Bessel's inequality is?	1	2	3
11. Gibb's phenomenon	Have you heard of the Gibb's phenomenon?	1	2	3
	Do you know what the Gibb's phenomenon is?	1	2	3
	Do you know why the Gibb's phenomenon occurs at points of discontinuity?	1	2	3
12. e^{ix}	Are you familiar with the function e^{ix}?	1	2	3
	Do you know Euler's identity for e^{ix}?	1	2	3
	Can you prove that the functions e^{imx} are orthogonal over 0 to 2π?	1	2	3
13. Convolution	Do you know what a convolution is?	1	2	3
	Do you know the convolution theorems?	1	2	3
	Can you state the two convolution theorems for the Fourier series?	1	2	3
14. Windows	Have you heard of windows in the Fourier series theory?	1	2	3
	Do you know what a window is?	1	2	3
	Can you describe the Lanczos' window?	1	2	3

		No	Uncertain	Yes
15. Digital filters	Can you design a digital filter?	1	2	3
	Do you know what a low pass filter is?	1	2	3
	Can you compute the coefficients of a low pass filter that passes the lower half of the Nyquist interval?	1	2	3
16. Differentiation	Do you know if the process of differentiating data is a digital filter?	1	2	3
	Do you know why numerical differentiation is difficult?	1	2	3
	Do you know what the transfer function of a differentiator is?	1	2	3
17. Fourier Integral	Do you know anything about the Fourier integral?	1	2	3
	Do you know how Fourier integrals are related to Fourier series?	1	2	3
	Can you give the two formulas for the Fourier integral?	1	2	3
18. Sampling theorem	Have you heard of the sampling theorem?	1	2	3
	Can you define the sampling theorem?	1	2	3
	Can you write the formula and conditions on the sampling theorem?	1	2	3
19. Band limited functions	Are you acquainted with the concept of band limited functions?	1	2	3
	Can you define a band limited function?	1	2	3
	Do you know what the importance of band limited functions is?	1	2	3

		No	Uncertain	Yes
20. Sample size	Are you acquainted with the problem of sample size?	1	2	3
	Do you know what the affect of a finite sample is on statistics?	1	2	3
	Do you know what the window is that corresponds to taking a finite sample?	1	2	3
21. Fast Fourier transform	Have you heard of the Fast Fourier Transform?	1	2	3
	Can you define the Fast Fourier Transform?	1	2	3
	Do you know if the Fast Fourier transform differs from the finite Fourier transform?	1	2	3
22. Finite Fourier series	Are you familiar with the finite Fourier series?	1	2	3
	Do you know about the orthogonality of the Fourier functions over a discrete set of points?	1	2	3
	Do you know how to get a finite Fourier expansion?	1	2	3
23. Recursive filter	Have you ever used a recursive filter?	1	2	3
	Can you define a recursive filter?	1	2	3
	Do you believe you could design a recursive filter with the aid of the textbook examples?	1	2	3
24. Butterworth filter	Have you heard of Butterworth filters?	1	2	3
	Can you define a Butterworth filter?	1	2	3
	Can you design Butterworth filters?	1	2	3

		No	Uncertain	Yes
25. Chebyshev criterion	Have you ever heard of the Chebyshev criterion?	1	2	3
	Can you define the Chebyshev criterion?	1	2	3
	Do you know what a Chebyshev filter is?	1	2	3

III. Specific Background Information

Answer the following ten questions as completely as you can within the 45 minutes allotted for the pretest. If you cannot answer a question go on to the next question.

1. Write out the formula for a digital filter.

2. Compute the difference operator's transfer function.

3. State the two convolution theorems for the Fourier series.

4. Describe the Lanczo's window.

5. What is the transfer function of a differentiator?

6. What is the importance of band limited functions?

7. Does the fast Fourier transform differ from the finite Fourier transform?

8. How did you get a finite Fourier expansion?

9. What is a recursive filter?

10. What is a Chabyshev filter?

DF-4

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CENTER FOR THE STUDY OF EVALUATION
UCLA GRADUATE SCHOOL OF EDUCATION
LOS ANGELES, CALIFORNIA 90024

January 2, 1980

Dear Short Course Participant:

It has been four months since you completed our Digital Filters short course. As you will recall we are conducting a study on the effectiveness of the short course learning mode. As part of this study we requested your cooperation in completing two follow-up questionnaires. The enclosed questionnaire is the second and last questionnaire you will be asked to complete. At the conclusion of the project you will receive an abstract of the study.

Please complete the attached questionnaire and return to us in the enclosed envelope. It is important that you do not spend more than 45 minutes on the questions and that you do not consult reference materials.

Thank you for your continuing cooperation. I am sure it will assist us in improving the effectiveness of future short courses.

Sincerely,

a c Ingersoll

A. C. Ingersoll, P. E.
Director

ACI:mm

DF-4

ID (7 digits)________________

SHORT COURSE FOLLOW-UP QUESTIONNAIRE 2

This measure will be used solely for the purpose of assessing short course effectiveness: Student responses will be kept strictly confidential.

I. Course Evaluation

	excellent	good	satisfactory	poor	unsatisfactory
1. Content	1	2	3	4	5
2. Presentation	1	2	3	4	5
3. Materials (e.g. text, notes, viewgraphs)	1	2	3	4	5

4.
How could the short course have been more effective in helping you achieve your objectives?

II. Specific Background Information

Answer the following ten questions as completely as you can within the 45 minutes allotted for the pretest. If you cannot answer a question go on to the next question.

1. In the context that a filter processes measurement to produce estimates of a state, what is the distinction between a linear and nonlinear filter?

2. Give verbal definitions/discussions of the notion of stationarity and ergodicity for a random process.

3. Write down the discrete-time dynamics and measurement model equations for which the basic discrete-time Kalman Filter applies. necessary to include all the assumption and properties of these model equations.

4. Delineate major steps involved in a Kalman filtering application.

5. Discuss the "goodness" of a Kalman Filter for an application which has linear models but statistics which are not Gaussian.

6. Discuss techniques for computing the process noise covariance matrix Q (K) in a discrete-time Kalman filtering problem.

7. Suppose that difficulty is experienced in an extented Kalman Filter design (the filter isn't functioning properly at all). What are some well-known changes that can be made to effect a possible cure.

KF-1

ID (7 digits) ____________

SHORT COURSE PARTICIPANT PRETEST

This measure will be used solely for the purpose of assessing short course effectiveness: Student responses will be kept strictly confidential.

I. Background Information

1. What is your educational background?

Degree	Institution	Major/Specialization	Year

2. Work assignment/Current job responsibility

- __ Industry
- __ Government
- __ Education
- __ Private Practitioner
- __ Other, please specify

  ____

- __ Technical/design
  - __ Research
  - __ Management
  - __ Operations
  - __ Sales
- __ Management
- __ Education
- __ Sales
- __ Operation
- __ Other, please specify

  ____

3. Why are you taking this course? What are your objectives?

II. Background and Course Related Concepts

Answer the following questions as completely as you can within the 45 minutes allotted for the pretest. If you cannot answer a question go on to the next question.

1. In Probability Theory, the expectation operator E is of fundamental importance. Explain in words and/or with an equation what the expectation operator is.

2. Discuss briefly the concept of state. Give a definition of a state vector for a dynamical system.

3. Explain what is meant by a Markov sequence as could result, for example, as a solution to a difference equation with a random forcing function which is a white sequence.

4. What are the general ideas associated with minimum-mean-square-error and minimum-variance estimation.

5. In the context that a filter processes measurements to produce estimates of a state, what is the distinction between a linear and a nonlinear filter?

6. What is the solution in general form of the following vector-matrix differential equation?

$$\dot{\underline{x}}(t) = F(t)\ \underline{x}(t) + G(t)\ \underline{u}(t)$$

7. Describe a physical problem for which a Kalman Filter could be applied. Identify the state (what is to be estimated), the measurements (available for doing the estimation process), and the models. The latter refers to the state dynamical model and the measurement/state relationship (measurement model). This whole description should be general and not mathematical.

ID (7 digits) ____________________

SHORT COURSE PARTICIPANT POSTTEST

This measure will be used solely for the purpose of assessing short course effectiveness: Student responses will be kept strictly confidential.

I. Course Evaluation

1. Clarity of presentation

   a. Excellent
   b. Good
   c. Satisfactory
   d. Poor
   e. Unsatisfactory

2. Continuity and order of the presentation

   a. Excellent
   b. Good
   c. Satisfactory
   d. Poor
   e. Unsatisfactory

3. Speed of delivery

   a. Much too fast
   b. A little too fast
   c. Just right
   d. A little too slow
   e. Much too slow

4. Presentation of:

	unsatisfactory	poor	satisfactory	good	excellent
a. Background material	1	2	3	4	5
b. Theory development	1	2	3	4	5
c. Examples	1	2	3	4	5
d. Applications	1	2	3	4	5
e. Procedures	1	2	3	4	5

5. Ability to hold your attention and interest

   a. Excellent
   b. Good
   c. Satisfactory
   d. Poor
   e. Unsatisfactory

6. Quality of visual presentation.

   a. Excellent
   b. Good
   c. Satisfactory
   d. Poor
   e. Unsatisfactory

7. Contribution of visual presentation to your understanding.

   a. Excellent
   b. Good
   c. Satisfactory
   d. Poor
   e. Unsatisfactory

8. Did the course provide adequate preparation so that you could use Kalman filters in your work?

   a. Excellent
   b. Good
   c. Satisfactory
   d. Poor
   e. Unsatisfactory

9. Additional Comments. Please comment on any specific aspects of the presentation which influenced the effectiveness of the course.

II. Course Related Concepts

Answer the following question as completely as you can within the 45 minutes allotted for the posttest. If you cannot answer a question go on to the next question.

1. Write the discrete-time dynamics and measurement model equations for which the basic discrete-time Kalman Filter applies. It is not necessary to include all the assumptions and properties of these model equations.

2. Write the equations for the basic discrete-time Kalman Filter.

3. Delineate the major steps involved in a Kalman Filtering application.

4. Discuss the "goodness" of a Kalman Filter for an application which has linear models but statistics which are not gaussian.

5. Discuss techniques for computing the process noise covariance matrix $Q(k)$ in a discrete-time Kalman Filtering problem.

6. Suppose that difficulty is experienced in an Extended Kalman Filter design (the filter isn't functioning properly at all). What are some well-known changes that can be made to effect a possible cure?

7. Describe briefly a real application in your field of expertise for which a Kalman Filter might be used. Identify the state and the measurements.

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UNIVERSITY EXTENSION
Continuing Education in Engineering and Mathematics

6266 Boelter Hall, UCLA
Los Angeles, California 90024

KF-3

October 5, 1979

Dear Participant in "Kalman Filters" Short Course:

It is now just four weeks since you completed our Kalman Filters short course, given at UCLA, August 27 to August 31, 1979. As you will recall, we requested your cooperation in a study we have under way on the effectiveness of the short course learning mode. This is the first of two follow-up communications you will receive from us. The second will come along in another three months.

Please complete the attached questionnaire and return to us in the enclosed reply envelope.

It is important that you spend no more than 45 minutes on the questions and further, that you do not consult reference materials or others. Of course this means also that you should not "bone up" on the subject before you open the questionnaire.

You already know, of course, that your response is totally confidential, since we have only your 7-digit identification number to relate to your earlier responses. If you have forgotten the number you put on your previous papers, please write or call me and hopefully we can reconstruct your "statistical identity."

At the conclusion of the project you will receive an abstract of the study.

On behalf of UCLA Extension and the University of Maryland Center of Continuing Education, I wish again to express appreciation for your cooperation. Whatever the outcome of the study it will surely assist us in improving the effectiveness of future short courses.

Please call me (collect if you wish) at (213) 825-4950 if you have any questions. I do look forward to seeing you again in a UCLA short course.

Sincerely,

A C Ingersoll

A. C. Ingersoll, P. E.
Director

ACI:MM

Attachment

KP-3

ID (7 digits)____________________

SHORT COURSE FOLLOW-UP QUESTIONNAIRE 1

This measure will be used solely for the purpose of assessing short course effectiveness: Student responses will be kept strictly confidential.

I. Course Evaluation

1. Please check the objective which most closely identifies the purpose you had in coming to this course, at the time you enrolled. If more than one item applies, please assign priority, e.g., 1, 2, 3, etc.

2. Circle the number indicating how well the short course satisfied each of the objectives you checked.

	excellent	good	satisfactory	poor	unsatisfactory
____To get an introduction to the theory of Kalman filtering.	a	b	c	d	e
____To get a review of the theory of Kalman filtering.	a	b	c	d	e
____To learn applications and applicability of Kalman filtering.	a	b	c	d	e
____To learn the language (i.e., a kind of "appreciation" course about Kalman filters) in order to communicate with others engaged in Kalman filtering.	a	b	c	d	e
____To gain an overview in preparation for possible future involvement in Kalman filtering.	a	b	c	d	e
____To be able to teach this subject in my organization.	a	b	c	d	e

____Other (please specify)______________________________

____

____

____

____

3. How much time did you spend studying outside of class during the course?

    a. none
    b. 1-4 hours
    c. 5-8 hours
    d. more than 8 hours

4. How much time have you spent studying the text or class notes since completing the course?

    a. none
    b. 1-4 hours
    c. 5-8 hours
    d. more than 8 hours

5. Have you applied the theory and procedures you learned in the short course in your work?

    a. yes
    b. no

6. How do you rate the Kalman filters short course at this time?

    a. excellent
    b. good
    c. satisfactory
    d. poor
    e. unsatisfactory

II. Background and Course Related Concepts

Answer the following questions as completely as you can within the 45 minutes allotted for the follow-up questionnaire. If you cannot answer a question go on to the next question.

1. The concept of an average value, or a mean value of a random variable is commonly used. What is a conditional mean of a random variable?

2. Discuss briefly the concept of state. Give a definition of a state vector for a dynamical system.

3. List by name at least four estimators which yield a common result for a linear measurement/state model.

4. Write the equations for the basic discrete-time Kalman filters.

5. Delineate the major steps involved in a Kalman filtering application.

6. What is the difference between a linearized Kalman filter and an extended Kalman filter?

7. Discuss the expectation operator E in the context of Kalman filtering optimality. That is, explain in layman's terms Kalman filtering optimality.

KF-4

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CENTER FOR THE STUDY OF EVALUATION
UCLA GRADUATE SCHOOL OF EDUCATION
LOS ANGELES, CALIFORNIA 90024

January 9, 1980

Dear Short Course Participant:

It has been four months since you completed our Kalman Filters short course. As you will recall we are conducting a study on the effectiveness of the short course learning mode. As part of this study we requested your cooperation in completing two follow-up questionnaires. The enclosed questionnaire is the second and last questionnaire you will be asked to complete . At the conclusion of the project you will receive an abstract of the study.

Please complete the attached questionnaire and return to us in the enclosed envelope. It is important that you do not spend more than 45 minutes on the questions and that you do not consult reference materials:

Thank you for your continuing cooperation. I am sure it will assist us in improving the effectiveness of future short courses.

Sincerely,

A C Ingersoll

A. C. Ingersoll, P. E.
Director

ACI:mm

KF-4

ID (7 digits)____________

SHORT COURSE FOLLOW-UP QUESTIONNAIRE 2

This measure will be used solely for the purpose of assessing short course effectiveness: Student responses will be kept strictly confidential.

I. Course Evaluation

	excellent	good	satisfactory	poor	unsatisfactory
1. Content	1	2	3	4	5
2. Presentation	1	2	3	4	5
3. Materials (e.g. text, notes, viewgraphs)	1	2	3	4	5

4. How could the short course have been more effective in helping you achieve your objectives?

II. Acquaintance With Background And Course Related Concepts

Read each of the following questions and circle the number which represents your belief about your ability to answer the question. The first question asks for vague knowledge of the concept. The second question asks for specific knowledge. The third question asks about a specific case.

		No	Uncertain	Yes
1. Digital filter	Do you know what a digital filter is?	1	2	3
	Can you accurately define a digital filter?	1	2	3
	Can you write the formula for a digital filter?	1	2	3
2. Statistics	Have you had some statistics?	1	2	3
	Are you familiar with the concepts distribution, mean, and variance?	1	2	3
	Can you find the variance for uniform roundoff?	1	2	3
3. Eigenfunction	Do you know what an eigenfunction is?	1	2	3
	Do you know why eigenfunctions are important?	1	2	3
	Do you know the eigenfunctions of linear systems?	1	2	3
4. Aliasing	Do you know what aliasing is?	1	2	3
	Do you know why aliasing is important in digital filters?	1	2	3
	Can you prove by trigonometry that aliasing must occur under sampling at equally spaced intervals?	1	2	3
5. Principle of	Are you acquainted with the principle of least squares?	1	2	3
	Can you state the principle of least squares?	1	2	3

		No	Uncertain	Yes
	Can you fit a straight line to the data $y(-2)$, $y(-1)$, $y(0)$, $y(1)$, and $y(2)$ using least squares principle?	1	2	3
6. Transfer function	Do you know what a transfer function is?	1	2	3
	Can you describe how to find a transfer function of a digital filter?	1	2	3
	Can you give the transfer function of the formula $y_n = \frac{-3x_{n-2}+12x_{n-1}+17x_n+12x_{n+1}-3x_{n+2}}{35}$? where the data are $\{x_n\}$?	1	2	3
7. Digital filter	Do you know what recursive and nonrecursive filters are?	1	2	3
	Can you define a recursive filter?	1	2	3
	Do you know why integration must be a recursive filter?	1	2	3
8. Finite differences	Do you know much about finite differences?	1	2	3
	Can you write the difference table of the squares of the first five integers?	1	2	3
	Can you compute the transfer function of the difference operator?	1	2	3
9. Orthogonality	Do you know why orthogonality is an important topic?	1	2	3
	Can you define what is meant by two functions being orthogonal?	1	2	3

		No	Uncertain	Yes
	Can you prove that sin mx and cos nx are orthogonal over the interval 0 to π?	1	2	3
10. Fourier series	Are Fourier series and least squares related?	1	2	3
	Can you give the relationship between least squares and Fourier series?	1	2	3
	Do you know what Bessel's inequality is?	1	2	3
11. Gibb's phenomenon	Have you heard of the Gibb's phenomenon?	1	2	3
	Do you know what the Gibb's phenomenon is?	1	2	3
	Do you know why the Gibb's phenomenon occurs at points of discontinuity?	1	2	3
12. e^{ix}	Are you familiar with the function e^{ix}?	1	2	3
	Do you know Euler's identity for e^{ix}?	1	2	3
	Can you prove that the functions e^{imx} are orthogonal over 0 to 2π?	1	2	3
13. Convolution	Do you know what a convolution is?	1	2	3
	Do you know the convolution theorems?	1	2	3
	Can you state the two convolution theorems for the Fourier series?	1	2	3
14. Windows	Have you heard of windows in the Fourier series theory?	1	2	3
	Do you know what a window is?	1	2	3
	Can you describe the Lanczos' window?	1	2	3

		No	Uncertain	Yes
15. Digital filters	Can you design a digital filter?	1	2	3
	Do you know what a low pass filter is?	1	2	3
	Can you compute the coefficients of a low pass filter that passes the lower half of the Nyquist interval?	1	2	3
16. Differentiation	Do you know if the process of differentiating data is a digital filter?	1	2	3
	Do you know why numerical differentiation is difficult?	1	2	3
	Do you know what the transfer function of a differentiator is?	1	2	3
17. Fourier Integral	Do you know anything about the Fourier integral?	1	2	3
	Do you know how Fourier integrals are related to Fourier series?	1	2	3
	Can you give the two formulas for the Fourier integral?	1	2	3
18. Sampling theorem	Have you heard of the sampling theorem?	1	2	3
	Can you define the sampling theorem?	1	2	3
	Can you write the formula and conditions on the sampling theorem?	1	2	3
19. Band limited functions	Are you acquainted with the concept of band limited functions?	1	2	3
	Can you define a band limited function?	1	2	3
	Do you know what the importance of band limited functions is?	1	2	3

		No	Uncertain	Yes
20. Sample size	Are you acquainted with the problem of sample size?	1	2	3
	Do you know what the effect of a finite sample is on statistics?	1	2	3
	Do you know what the window is that corresponds to taking a finite sample?	1	2	3
21. Fast Fourier transform	Have you heard of the Fast Fourier Transform?	1	2	3
	Can you define the Fast Fourier Transform?	1	2	3
	Do you know if the Fast Fourier transform differs from the finite Fourier transform?	1	2	3
22. Finite Fourier series	Are you familiar with the finite Fourier series?	1	2	3
	Do you know about the orthogonality of the Fourier functions over a discrete set of points?	1	2	3
	Do you know how to get a finite Fourier expansion?	1	2	3
23. Recursive filter	Have you ever used a recursive filter?	1	2	3
	Can you define a recursive filter?	1	2	3
	Do you believe you could design a recursive filter with the aid of the textbook examples?	1	2	3
24. Butterworth filter	Have you heard of Butterworth filters?	1	2	3
	Can you define a Butterworth filter?	1	2	3
	Can you design Butterworth filters?	1	2	3

		No	Uncertain	Yes
25. Chebyshev criterion	Have you ever heard of the Chebyshev criterion?	1	2	3
	Can you define the Chebyshev criterion?	1	2	3
	Do you know what a Chebyshev filter is?	1	2	3

III. Specific Background Information

Answer the following ten questions as completely as you can within the 45 minutes allowed for the pretest. If you cannot answer a question go on to the next question.

1. Write the formula for a digital filter.

2. What are the eigenfunctions of linear systems?

3. Why must integration be a recursive filter?

4. What is Bessel's inequality?

5. Why does the Gibb's phenomenon occur at points of discontinuity?

6. Compute the coefficients of a low pass filter that passes the lower half of the Nyquist interval?

7. Write the formula and conditions on the sampling theorem.

8. What is the importance of band limited functions?

9. What is the window that corresponds to taking a finite sample?

10. What is a Butterworth filter?

APPENDIX 3

COMMUNICATIONS SENT TO COURSE PARTICIPANTS

DF - Digital Filters

KF - Kalman Filtering

- 1: Preregistration Information
- 2: Five-Week Questionnaire Letter
- 3: Five-Week Follow-Up Letter
- 4: Four-Month Questionnaire Letter
- 5: Four-Month Follow-Up Letter
- 6: Notification of Test Results

DF-1

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UNIVERSITY EXTENSION
Continuing Education in Engineering and Mathematics

6266 Boelter Hall, UCLA
Los Angeles, California 90024

June, 1979

To Participant in Short Course "Digital Filters":

You have preregistered in the UCLA Extension Course, "Digital Filters," to be coordinated by Dr. Richard Hamming, August 19-24, 1979. The purpose of this letter is to explain the Sunday evening session in addition to the customary five day short course.

In an ongoing effort to evaluate the effectiveness of our short course offerings, this summer UCLA Extension is engaging in a special study--in which we ask your cooperation. Please arrive at the Tudor Room, Holiday Inn-Westwood, 10740 Wilshire Blvd., West Los Angeles, CA., in time for the following schedule of Sunday evening activity:

6:00 pm Registration and backgroung assessment of course participants

7:00 pm Hosted social hour and dinner

8:30 pm Special lecture by Dr. Hamming, "The Unreasonable Effectiveness of Mathematics"

Later in the week on Friday morning, we shall again invite you to have breakfast as a group, followed by a 45-minute "Course Effectiveness Evaluation."

Both the background assessment and the course effectiveness evaluation are in the nature of questionnaires--well, maybe a little more like tests--but you are not expected to do any special preparation either before or during the week.

It is, of course, essential to maintain the confidentiality of test results, so that no results will ever be associated with the name of a course participant. Obviously we are interested only in the statistical results. For this purpose we shall ask each course participant to write on his paper on Sunday (and again on Friday) a 7-digit number which will mean something only to him/her.

Should you be unable for any reason to join us Sunday evening, please contact me at (213) 825-4950 or write to the above address to see how we may work out an alternative routing in your case. It is very important that we engage the entire class of short course participants in the study. On the other hand, should you feel any reluctance in participating, we don't want you to stay away from the course on that account alone, and that is why I want you to talk it over with me.

I surely look forward to seeing you this summer.

Sincerely,

A. C. Ingersoll, P.E.
Director

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6266 Boelter Hall, UCLA
Los Angeles, California 90024

DF-2

August 31, 1979

Dear Participant in "Digital Filters" Short Course:

It is now just four weeks since you completed our Digital Filters short course, given at the University of Maryland, July 29 to August 4, 1979. As you will recall, we requested your cooperation in a study we have under way on the effectiveness of the short course learning mode. This is the first of two follow-up communications you will receive from us. The second will come along in another three months.

Please complete the attached questionnaire and return to us in the enclosed reply envelope.

It is important that you spend no more than 45 minutes on the questions and further, that you do not consult reference materials or others. Of course this means also that you should not "bone up" on the subject before you open the questionnaire.

You already know, of course, that your response is totally confidential, since we have only your 7-digit identification number to relate to your earlier responses. If you have forgotten the number you put on your previous papers, please write or call me and hopefully we can reconstruct your "statistical identity."

At the conclusion of the project you will receive an abstract of the study.

On behalf of UCLA Extension and the University of Maryland Center of Continuing Education, I wish again to express appreciation for your cooperation. Whatever the outcome of the study it will surely assist us in improving the effectiveness of future short courses.

Please call me (collect if you wish) at (213) 825-4950 if you have any questions. I do look forward to seeing you again in a UCLA short course.

Sincerely,

A. C. Ingersoll

A. C. Ingersoll, P.E.
Director

ACI:jb

Attachment

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DF-3

November 12, 1979

Dear Short Course Participant:

When you took the Digital Filters or Kalmar Filters short course you were informed that we are engaged in a study which will help us offer better short courses in the future. You will recall completing a questionnaire before you started the course and another on the last day of the course.

You should have received a mailing from us, with a follow-up questionnaire, four or five weeks after course completion. If you have already returned this in the envelope provided, many thanks.

If you have not returned the follow-up questionnaire, would you please help us by doing so at your very earliest convenience? Without the follow-up measure of retention we are without vital information for completion of the study, and we are truly anxious to learn what we can from this project. If you have lost (or did not receive the mailing) please call me collect at (213) 825-4950 and we'll shoot you a replacement pronto.

And please remember to use your confidential 7-digit identification number, so we can match the results with your earlier responses.

When the study is completed you will receive a summary of our findings. Thank you for your cooperation.

Sincerely,

A C Ingersoll

A. C. Ingersoll, P. E.
Director

DF-4

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LOS ANGELES, CALIFORNIA 90024

January 2, 1980

Dear Short Course Participant:

It has been four months since you completed our Digital Filters short course. As you will recall we are conducting a study on the effectiveness of the short course learning mode. As part of this study we requested your cooperation in completing two follow-up questionnaires. The enclosed questionnaire is the second and last questionnaire you will be asked to complete. At the conclusion of the project you will receive an abstract of the study.

Please complete the attached questionnaire and return to us in the enclosed envelope. It is important that you do not spend more than 45 minutes on the questions and that you do not consult reference materials.

Thank you for your continuing cooperation. I am sure it will assist us in improving the effectiveness of future short courses.

Sincerely,

A C Ingersoll

A. C. Ingersoll, P. E.
Director

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LOS ANGELES, CALIFORNIA 90024

Dear Short Course Participant:

At the time you participated in the Digital Filters short course you were asked to cooperate in a study we are conducting on the effectiveness of the short course learning mode. Several weeks ago you received the second follow-up questionnaire. If you have already returned this questionnaire please disregard this letter. If you have not yet completed this questionnaire please complete the attached questionnaire and return in the enclosed envelope. It is important that you do not spend more then 45 minutes on the questions and that you do not consult reference materials.

Thank you for your cooperation. You will receive an abstract of the study results as soon as they are available.

Sincerely,

A C Ingersoll

A. C. Ingersoll, P. E.
Director

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DF-6

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6266 Boelter Hall, UCLA
Los Angeles, California 90024

June 30, 1980

TO: Participants in 1979 Short Courses, "Digital Filters" and "Kalman Filtering"

Dear Friends:

You will recall, at the time that you took one of the above courses last year, either at UCLA or the University of Maryland, that we asked you to participate in a study to improve the effectiveness of the short course method of continuing education in engineering, science and mathematics. These two courses had been selected because they were similar in nature, strongly oriented toward applied mathematics, and the instructors were enthusiastic to engage in the study.

Each course was taught twice by the same instructor, once utilizing a conventional lecture-with-blackboard approach, and once with extensive use of view graph transparencies. You will doubtless recall which part of the test you were in. You will remember completing a demographic identification, a cognitive pretest, plus cognitive and affective posttest and two follow-up questionnaires at five weeks and four months.

A total of 129 course participants took the pretest, while 132 took the posttest at the end of each 5-day class. The mail response to the follow-up questionnaires was drastically diminished, 37 at five weeks and 36 at four months.

It was recognized that the study could yield three kinds of positive outcome, viz. (i) both courses yield the blackboard to be superior to the viewgraph, (ii) vice versa, (iii) both courses yield no significant difference in cognitive achievement of learning objectives. It was this third case which was actually realized in the study. While this may have disappointed some who were betting on a clear victory for one method over the other, it was much better than the inconclusive outcome that would have resulted from one course yielding one of the above results while the other yielded a different one.

You will probably not be surprised to learn that in terms of what course participants liked (affective response) there was an identifiable (although not overwhelming) preference for the view graph mode of presentation.

Although no test was conducted on a class given only the blackboard or view graph communication (that is, with no textbook or notes), it is clear that such a mode would have been totally unacceptable to participants paying the listed course fee. Participant response is very clear on the subject of quality handout materials and these will always be a feature of UCLA short courses.

On behalf of UCLA Extension I want to thank you for your willingness to be a part of this study last year. Future short courses at UCLA will almost always involve some visual presentations with view graph and some conventional lecturing. This would doubtless happen, even without the study, but now we can at least have the peace of mind that tells us that the method of presentation doesn't matter all that much. What does matter is the overall technical and lecturing competence of the instructor, the currency of his information and the quality of materials prepared for distribution to the course participants.

I hope that we shall see you in future short courses here or at the University of Maryland. Please don't hesitate to write or call me at 213/825-4950 if you have a suggestion for a short course you would like to see us do, and also someone to coordinate it.

With all good wishes for your continued successful professional development,

Sincerely,

A. C. Ingersoll

A. C. Ingersoll, P.E.
Director

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6266 Boelter Hall, UCLA
Los Angeles, California 90024

June, 1979

To Participant in Short Course "Kalman Filtering":

You have preregistered in the UCLA Extension Course, "Kalman Filtering", to be coordinated by Dr. Joseph LeMay, August 26-31, 1979. The purpose of this letter is to explain the Sunday evening session in addition to the customary five day short course

In an ongoing effort to evaluate the effectiveness of our short course offerings, this summer UCLA Extension is engaging in a special study--in which we ask your cooperation. Please arrive at the Tudor Room, Holiday Inn - Westwood, 10740 Wilshire Blvd., West Los Angeles, CA., in time for the following schedule of Sunday evening activity:

6:00 pm Registration and background assessment of course participants

7:00 pm Hosted social hour and dinner

8:30 pm Lecture by Dr. LeMay, "Kalman Filtering Introduction and Overview".

Later in the week, on Friday noon, we shall again invite you to have lunch as a group, follwed by a 45-minute "Course Effectiveness Evaluation".

Both the background assessment and the course effectiveness evaluation are in the nature of questionnaires -- well, maybe a little more like tests -- but you are not expected to do any special preparation either before or during the week.

It is, of course, essential to maintain the confidentiality of test results, so that no results will ever be associated with the name of a course participant. Obviously we are interested only in the statistical results. For this purpose we shall ask each course participant to write on his/her paper on Sunday (and again on Friday) a 7-digit number which will mean something only to him/her.

Should you be unable for any reason to join us Sunday evening, please contact me a (213) 825-4950 or write to the above address to see how we may work out an alternative routing in your case. It is very important that we engage the entire class of short course participants in the study. On the other hand, should you feel any reluctance in participating, we don't want you to stay away from the course on that account alone, and that is why I want you to talk it over with me.

I surely look forward to seeing you this summer,

Sincerely,

A.C. Ingersoll, P.E.
Director

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Los Angeles, California 90024

XF-2

October 5, 1979

Dear Participant in "Kalman Filters" Short Course:

It is now just four weeks since you completed our Kalman Filters short course, given at UCLA, August 27 to August 31, 1979. As you will recall, we requested your cooperation in a study we have under way on the effectiveness of the short course learning mode. This is the first of two follow-up communications you will receive from us. The second will come along in another three months.

Please complete the attached questionnaire and return to us in the enclosed reply envelope.

It is important that you spend no more than 45 minutes on the questions and further, that you do not consult reference materials or others. Of course this means also that you should not "bone up" on the subject before you open the questionnaire.

You already know, of course, that your response is totally confidential, since we have only your 7-digit identification number to relate to your earlier responses. If you have forgotten the number you put on your previous papers, please write or call me and hopefully we can reconstruct your "statistical identity."

At the conclusion of the project you will receive an abstract of the study.

On behalf of UCLA Extension and the University of Maryland Center of Continuing Education, I wish again to express appreciation for your cooperation. Whatever the outcome of the study it will surely assist us in improving the effectiveness of future short courses.

Please call me (collect if you wish) at (213) 825-4950 if you have any questions. I do look forward to seeing you again in a UCLA short course.

Sincerely,

A C Ingersoll

A. C. Ingersoll, P. E.
Director

ACI:MM

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6266 Boelter Hall, UCLA
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November 12, 1979

Dear Short Course Participant:

When you took the Digital Filters or Kalmar Filters short course you were informed that we are engaged in a study which will help us offer better short courses in the future. You will recall completing a questionnaire before you started the course and another on the last day of the course.

You should have received a mailing from us, with a follow-up questionnaire, four or five weeks after course completion. If you have already returned this in the envelope provided, many thanks.

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And please remember to use your confidential 7-digit identification number, so we can match the results with your earlier responses.

When the study is completed you will receive a summary of our findings. Thank you for your cooperation.

Sincerely,

A C Ingersoll

A. C. Ingersoll, P. E.
Director

KF-4

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LOS ANGELES, CALIFORNIA 90024

January 9, 1980

Dear Short Course Participant:

It has been four months since you completed our Kalman Filters short course. As you will recall we are conducting a study on the effectiveness of the short course learning mode. As part of this study we requested your cooperation in completing two follow-up questionnaires. The enclosed questionnaire is the second and last questionnaire you will be asked to complete . At the conclusion of the project you will receive an abstract of the study.

Please complete the attached questionnaire and return to us in the enclosed envelope. It is important that you do not spend more than 45 minutes on the questions and that you do not consult reference materials:

Thank you for your continuing cooperation. I am sure it will assist us in improving the effectiveness of future short courses.

Sincerely,

A C Ingersoll

A. C. Ingersoll, P. E.
Director

ACI:mm

KF-5

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UCLA GRADUATE SCHOOL OF EDUCATION
LOS ANGELES, CALIFORNIA 90024

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At the time you participated in the Kalman Filters short course you were asked to cooperate in a study we are contucting on the effectiveness of the short course learning mode. Several weeks ago you received the second follow-up questionnaire. If you have not yet completed this questionnaire please complete the attached questionnaire and return in the enclosed envelope. It is important that you do not spend more than 45 minutes on the questions and that you do not consult reference materials.

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Sincerely,

a C Ingersoll

A. C. Ingersoll, P.E.
Director

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Continuing Education in Engineering and Mathematics

6266 Boelter Hall, UCLA
Los Angeles, California 90024

June 30, 1980

TO: Participants in 1979 Short Courses, "Digital Filters" and "Kalman Filtering"

Dear Friends:

You will recall, at the time that you took one of the above courses last year, either at UCLA or the University of Maryland, that we asked you to participate in a study to improve the effectiveness of the short course method of continuing education in engineering, science and mathematics. These two courses had been selected because they were similar in nature, strongly oriented toward applied mathematics, and the instructors were enthusiastic to engage in the study.

Each course was taught twice by the same instructor, once utilizing a conventional lecture-with-blackboard approach, and once with extensive use of view graph transparencies. You will doubtless recall which part of the test you were in. You will remember completing a demographic identification, a cognitive pretest, plus cognitive and affective posttest and two follow-up questionnaires at five weeks and four months.

A total of 129 course participants took the pretest, while 132 took the posttest at the end of each 5-day class. The mail response to the follow-up questionnaires was drastically diminished, 37 at five weeks and 36 at four months.

It was recognized that the study could yield three kinds of positive outcome, viz. (i) both courses yield the blackboard to be superior to the viewgraph, (ii) vice versa, (iii) both courses yield no significant difference in cognitive achievement of learning objectives. It was this third case which was actually realized in the study. While this may have disappointed some who were betting on a clear victory for one method over the other, it was much better than the inconclusive outcome that would have resulted from one course yielding one of the above results while the other yielded a different one.

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On behalf of UCLA Extension I want to thank you for your willingness to be a part of this study last year. Future short courses at UCLA will almost always involve some visual presentations with view graph and some conventional lecturing. This would doubtless happen, even without the study, but now we can at least have the peace of mind that tells us that the method of presentation doesn't matter all that much. What does matter is the overall technical and lecturing competence of the instructor, the currency of his information and the quality of materials prepared for distribution to the course participants.

I hope that we shall see you in future short courses here or at the University of Maryland. Please don't hesitate to write or call me at 213/825-4950 if you have a suggestion for a short course you would like to see us do, and also someone to coordinate it.

With all good wishes for your continued successful professional development,

Sincerely,

A. C. Ingersoll

A. C. Ingersoll, P.E.
Director

ACI:jb

APPENDIX 4

REPORTS OF OBSERVERS

a. Short Course Observation Procedures

b. Digital Filters Course Observations
Betty Johnson, Research Associate
Center for Study of Evaluation, UCLA

c. Kalman Filtering Course Observation
Patricia O'Brien, Research Assistant
University of Maryland, College Park, MD

SHORT COURSE OBSERVATION PROCEDURES

Objectives

1. Describe the teaching methods so others could replicate
2. Document how the two teaching methods differed

Procedures

1. Tape record two topics (same topic for both methods)
2. Observe entire course presentation attending to
    - How the view graphs were used (style of useage)
        - when introduced
        - content
        - length of display
        - how incorporated into lecture
    - How the two procedures differed
        - visual display (blackboard or viewgraph)
            - content
            - time of introduction
            - duration of display
            - nature of verbal explanation
        - teacher presentation (lecture)
            - content [what was said? how was it said?]
            - order of presentation
            - amount of amplification
            - affect/manner/enthusiasm
        - student behavior
            - attention
            - note taking - amount, content
            - questions - number, kind
            - use of printed materials (text, view graphs)
            - involvement
            - comments about course

Product

1. Written report summarizing your observations. Be sure to provide examples to illustrate any differences you observe.
2. Tapes

DIGITAL FILTERS COURSE OBSERVATION

Betty Johnson
Research Associate
Center for Study of Evaluation
University of California
Los Angeles, California

INTRODUCTION

This report summarizes the results of the observation of the Digital Filters Short Course. The observation was intended to provide information about similarities and differences in the blackboard and view graph teaching methods which might help us to understand any differences between the two methods in student satisfaction and/or achievement.

The observation of the Digital Filters classes at both the University of Maryland and UCLA was done by Betty Johnson. Mrs. Johnson is a Ph.D. candidate in educational psychology at UCLA and a member of the staff of the Center for the Study of Evaluation. She observed the entire presentation of each teaching mode and tape recorded two sessions of each class. In addition, she administered the pre and post tests and handled administrative tasks for the short course coordinators.

COMPARISON OF TEACHING METHODS

Both Digital Filters classes were taught by Dr. Richard Hamming. Dr. Hamming had taught the course a number of times using the standard blackboard method of instruction. He also wrote the textbook used for the course.

Students in both classes received copies of the textbook and printed notes for an additional topic not included in the textbook. Students in the view graph class also received a notebook containing copies of the view graphs.

The blackboard class was taught in a large, one level classroom. The blackboard was located at the front of the room. Rows of tables and chairs faced the blackboard with an aisle down the center of the room. Windows at the right side of the classroom caused some glare on the blackboard. This glare plus the size and configuration of the room made it difficult for the students in some seats to see the diagrams and equations written on the blackboard. In addition, the instructor wrote small and tended to cover the material he was writing with his body. He also dropped his voice at the end of his sentences as he was writing on the blackboard.

The viewgraph class was held in a typical lecture hall. The blackboard and lecturn were located at the lowest level. Student seating was elevated to enable each student to have a clear view. The blackboard was easy to see from all parts of the room. Two projectors flanked the instructor. One focused on a screen in the middle of the room directly behind the instructor. This projector was used for displaying the material that was being covered at the moment. A second projector focused on a screen to the right of the instructor. The projector was used for displaying the chapter outline or the previous slide. This allowed the instructor to refer to equations or diagrams which preceded the one he was discussing. The instructor faced the class as he talked and did not drop his voice at the end of sentences as often as in the blackboard class.

Both the blackboard and view graph classes were taught with a linear sequential type of presenation. The lectures closely paralleled the textbook for both classes. In addition to the Digital Filters course Dr. Hamming also taught a second "course within a course". The subject of this course was how to do research. Dr. Hamming interspersed his ideas about how to do research and anecdotes from his personal experience throughout the course. The timing and order of these topics was more varied than that of the digital filters course. They were often presented at the end of a session rather than proceeding to a new topic. This was especially true in the viewgraph class where the digital filter presentation was more tightly controlled by the view graphs. The "other" course was popular with most students. They found these presentations stimulating as well as a relief from the intensity of the digital filters course.

The primary difference between the two classes was that in the view graph class view graphs were used for displaying diagrams and equations which were written on the blackboard in the blackboard class. In general, the use of view graphs reduced the time required to present a topic. The use of view graphs eliminated the time required to write the equations as well as the time required to identify mistakes which the instructor made while developing the equations. There were, however, some mistakes in the view graphs. Most of these were identified by the instructor rather than the students. These mistakes would not be a factor the second time a class was presented using view graphs.

Although both classes followed the same organization as the textbook, the view graph class appeared to have a tighter structure. Slides were presented at the beginning of each topic which outlined the sequence of development. The use of view graphs kept the instructor closely tied to this outline. The difference in the two methods was most apparent in the introductory lecture. The introduction was much better organized in the view graph class. The course and chapter outlines were displayed and each subsequent view graph served as a stimulus for the topic to be covered. The introductory lecture in the blackboard class was less well organized. The instructor did not provide an overview of the course or the first chapter. He skipped over some topics very quickly leaving the class somewhat bewildered.

There was some difference in the content of the two classes. The blackboard class sometimes included intermediate equations which were not included in the text. The view graph presentation was limited to the equations in the text.

The instructor used the blackboard in the view graph class to draw diagrams and write equations required to answer students' questions. As the week progressed the use of the blackboard was also extended to drawing diagrams and writing equations used in the review of the course content. This use of the blackboard increased because of the difficulty of locating a particular view graph as the total number of view graphs increased. The instructor also reduced the amount of writing on the blackboard by referring to equations and diagrams in the textbook. This procedure became more prevalent near the end of the week.

Students in the view graph class made notes directly on the view graphs. This eliminated the need to copy the equations and allowed them to focus on the additional description. In general, notetaking was minimal in both classes since all important equations were included in the textbook. Although there appeared to be more notetaking in the blackboard class it was largely a function of the individual student. A few students took extensive notes throughout the class. Most did not.

Dr. Hamming was willing to answer all questions. He did ask students to postpone questions about specific realizations and applications until a session near the end of the course set aside for that purpose. He was available to talk to students during class breaks and a group of students was always clustered around him. Many questions were raised at those times.

Dr. Hamming's past experience suggested that there would be a time at which the class suddenly understood enough to ask questions. He planned the course to allow time to answer all of these questions. This occurred on Tuesday in the view graph class and on Wednesday in the blackboard class. The nature of the questions was the same in both classes and the time required to exhaust the supply of questions was similar (approximately two hours). A possible explanation for the difference in timing was that the basic material was covered more rapidly in the view graph class. However, Dr. Hamming said that this series of questions always occurred on the second or third day and he could not predict exactly when it would occur.

Dr. Hamming's strategy was to cover the material several times. He reviewed before going on to each new topic. Since the speed of presentation was somewhat faster in the view graph class there was also more time for review.

The students in both classes generally expressed positive opinions about the class. After the initial frustration was reduced everyone appeared to be comfortable with the basic concepts. Some students felt they were unable to fully understand the material because they did not have an adequate background in mathematics. A number of students in the view graph class said that they preferred view graphs to the traditional blackboard method of teaching.

KALMAN FILTERING COURSE OBSERVATION

or

WHAT IN THE HELL IS "BIG E"?

Patricia O'Brien
Research Assistant
University of Maryland
College Park, Maryland

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Introduction and Design

This report is a summary of the pre-and post-testing and observations made of the Kalman Filtering course taught by Dr. Joseph LeMay and Dr. William Brogan at University of California Los Angeles from August 26-31 and at University of Maryland from September 9-14. It is part of a National Science Foundation Grant to study the comparative effectiveness of two methodologies used in teaching two technical week-long courses of the National University Short Course Consortium. The "conventional" lecture/blackboard style with a linear sequential type of presentation was used at U.C.L.A., and the "visual analogue" approach in which the lecturers made almost exclusive use of projection transparencies and two "Vu-Graph" projectors to present facts, theory, applications and examples was used at the U. of Md. At U.C.L.A. students were provided a detailed copy of the lecture notes in notebook form, and at the University of Maryland they were provided a complete set of paper copies of the transparencies in notebook form.

The same pre-test was given to each group on the Sunday evening preceding the course, and the same post-test was administered to each group at noon on Friday immediately following the course. Observations were made and notes taken throughout the entire week (with the exception of approximately 1 1/2 hours at each location), and audio-cassette tapes were made of most of the presentations on Tuesday (per LeMay) of both instructors at each location. The introduction and overview presented by Dr. LeMay on Sunday evening at both locations was the same. It consisted primarily of a comprehensive preview of the content of the course using vu-graphs for the presentation.

COURSE GOALS, CONTENT AND ORGANIZATION

Appendix 1-I (page 101) is the Lifelong Learning brochure for the Kalman Filtering course. It contains general information about the course, instructors, and registration procedures. It gives a detailed description of the organization of the course and the content covered each day during the week. The course was "team" (or "turn"?) taught by the two instructors, and the brochure indicates the topics covered by each. In general, Dr. LeMay covered the more theoretical aspects, and Dr. Brogan covered in more detail the practical applications (see brochure) although both did some of each.

Pages 237 through 239 show the course goals, course contents, and definitions of "Kalman Filtering" that were provided during the introduction and overview.

TEACHING METHODOLOGIES

"Conventional" Lecture/Blackboard Method

1. Students at registration were given a large notebook of course notes divided into the major topics to be covered in the course. At the end of each topic were paper copies of several summary vu-graphs complete with written text, formulas, derivations, charts, references, etc. The content reads much like a regular textbook.

2. Large blackboards were located in the front of the room with chalk and erasers placed on a small ledge thereunder.

3. A large screen was available to pull down in front of the room when needed. An overhead projector was placed in the center front of the room so that it could be quickly turned on and used when needed to project vu-graphs on the screen.

4. Instructors, one at a time, stood or walked back and forth in front of the class.

5. Students all sat in seats facing forward.

6. Instructors initially faced the class and began the lecture from the notes they had on a lecturn in front of them. For almost the entire period (4-1½ hr sessions) each day they wrote formulas and graphs from right to left on the blackboards. Sometimes they would talk while writing, but generally they wrote in silence and then would turn toward the class to cover the material verbally, to stress certain points, etc.

7. Course content was presented in a linear, sequential fashion in the topical order designated in the brochure (see pg. 104). Emphasis was on building theory block upon block and introducing practical examples after the background theory was developed. (This approach is also called "teaching the student how to learn.")

8. Instructors continued this progress through the week filling the blackboards from left to right, erasing when the boards were filled, and continuing the process. At times formulas or content was left on one board to be used for reference during further derivations, etc.

9. At the end of each section of course content, instructors pulled down the screen, turned on the overhead projector, and projected vu-graphs on the screen which summarized briefly the content just covered. A pointer was used to point to whatever was being discussed on the vu-graph.

"Visual Analogue" Vu-Graph Method

1. Students at registration were given a large notebook of paper prints of the vu-graphs for the course with colored pages dividing each major topic to be covered. (Although the outline format and page numbers in each section made it possible to follow from one chart to the next, the general appearance was very different from the textbook or notes one is generally familiar with in a course. Formulas, charts, and word content lacked any explanation of where things came from or the rela-

tive importance of certain material or concepts, for example.) No references were provided in the notebook.

2. Blackboards (or "greenboards") were located across the front of the room with chalk and erasers placed on a small ledge thereunder.

3. An overhead projector and a medium-sized screen facing the students were located at both the right and left hand front of the room.

4. Instructors, one at a time, stood or walked back and forth in front of the class.

5. Students all sat in seats facing forward.

6. The instructor stood at one projector or the other and spent almost the entire period changing vu-graphs in sequence and talking continually about the content being projected. Frequently a pointer was used to refer to certain parts of a formula, etc. On rare occasions a formula or graph would be written on the blackboard.

7. Information, facts, graphs, and formulas were presented on the vu-graphs which were then discussed including examples, applications, relationships, etc. Topical organization was the same as in the conventional method (see pg. 104).

Instructors

Similarities

Both instructors are master teachers and experts in their field. They have a clear understanding of the theoretical background as well as practical experience with kalman filtering. Both have had prior experience team-teaching the same course together. This course content has been organized and refined over a period of years through their past experience with similar students in the same short-course format at U.C.L.A.

Both instructors had the same students and used the same classroom setting at each location. They adapted each presentation slightly to respond to needs of students in the class by answering student questions throughout each lecture/presentation.

Both instructors made themselves available to talk with students before and after class, during morning and afternoon coffee breaks, and at the several social gatherings (dinner, cocktail hour and luncheon provided by the program) at each institution.

Differences

Some differences in voice quality were apparent (see tapes): Dr. LeMay spoke more softly and with less tone variation, while Dr. Brogan's voice was louder and had greater tone variation. (Brogan was easier to hear.) Their blackboard writing style also varied: Dr. LeMay wrote more quickly, and his writing was generally larger and more even in size, while Dr. Brogan wrote more slowly, and wrote smaller characters that were somewhat uneven in size. (LeMay's writing was easier to read.) Dr. LeMay stayed very close to the original format for "conventional" and "vu-graph" methodologies, whereas Dr. Brogan during his first two lectures at U.C.L.A. adapted more to student questions and then used vu-graphs for a longer period of time in order to cover some topics more quickly (see tapes).

STUDENTS

Similarities

Students in both groups were rather quiet and reserved but friendly (no loud talking, laughter or touching like you might find at a convention of counselors, for example). Throughout the week, with a single exception, they appeared to be alert, interested, and following the presentation.

Most students played a rather passive role in terms of group interaction and remained silent during class throughout the week. A number of students asked questions or made comments. In each group, some students who spoke up did so repeatedly. (Most of the questions were asked by a few students.)

Differences

The group at UCLA was larger (72 participants), including two women, no blacks, several orientals, and several persons with foreign accents. At Maryland there were fewer participants (58), including six women, one black, several orientals, and several people with foreign accents.

At UCLA approximately one-half of the class took extensive notes on separate paper. (Several asked for additional tablets of paper.) At Maryland practically no one was observed taking notes on separate paper during the entire class. Some handwritten notes were made by a number of students on the paper prints of vu-graphs provided for the course. They made repeated requests for additional references.

Students clapped at the end of the program at UCLA, but did not clap at the University of Maryland.

Nearly everyone enrolled in the class stayed for the final luncheon on Friday afternoon at UCLA, whereas approximately 15 or more left early and did not attend the luncheon at the University of Maryland.

CONTENT AND PRESENTATION OBSERVATIONS

Similarities

The course introduction and overview was the same at both locations. It was done in vu-graph format with no use of blackboards. The same course content was covered in the same general topical order (See pgs. 102 and 104) using alternative methodologies throughout. Subject matter and content only was discussed (Not like Hamming's lectures which included values, professional responsibilities, career implications, etc.).

The instructors stood or walked back and forth in front of the class, whereas students sat in chairs facing the instructor. Instructors encouraged students to ask questions or make comments during the presentations. Very few other opportunities were provided during class time for students to give instructors feedback (Exception: Show of hands when LeMay asked class whether they were following him). No out-of-class assignments or suggested activities were given. No group methods or techniques were used other than the conventional or vu-graph methods (For example, there were no case studies, discussion groups, panels, field trips or tours, role-playing, brain-storming, etc.). No opportunity was provided for students to get any feedback from the instructors regarding their progress.

Instructors handled each methodolgy with facility. The vu-graph presentations were handled effectively whether a few transparencies were projected or dozens in a session.

Differences

The classroom settings differed at each location. UCLA's room was a large tiered, auditorium-style classroom with theater-like seats with optional desk-tops (See page 240). The large group of students sat scattered throughout the room, frequently one or more seats away from another student. Maryland's room, on the other hand, was a much smaller and more typical classroom with moveable tables and chairs that were arranged in rows with a center aisle and seats on only one side of the tables (See page 241). Students sat close together, and the classroom was completely filled. (Note: The classroom layouts are not in the same size scale.)

During the lecture presentation (UCLA) instructors used blackboards, chalk, and erasers extensively and the overhead projector and pointer infrequently and for a much more limited period. Microphones (stationary and hand-held) were used most of the time. During the vu-graph presentation (U. of Md.), instructors used the overhead projectors and pointer almost exclusively. Blackboards, chalk, and erasers were rarely used and then generally in response to a student question or for further amplification. Microphones (stationary and around-the-neck) were used about one-half of the time.

During the conventional method, instructors spent a large amount of time with their backs to the class, writing on the blackboards. They were often silent during this period. After writing, they would then turn to the class to continue lecturing. For the most part, instructors held a page of notes in hand (except for LeMay's three-hour Kalman Filter derivation, which was done entirely from memory). In the vu-graph method, instructors faced the class more and talked almost continually while presenting material. No notes were used other than the vu-graphs themselves. Very little class time was used with writing on the blackboards.

During the conventional method blackboard time was used for developing a logical presentation, doing derivations, etc. Vu-graphs were used briefly at the end of major topics, primarily for the purpose of summarizing content previously covered. The vu-graphs used were large type in black and white. During the vu-graphs method, the transparencies were projected and instructors spent the time talking about the theory, applications, how the formulas were derived, etc. Less summarization was done. Dr. LeMay used some colored vu-graphs (these were difficult to read from a distance), and Dr. Brogan used some vu-graphs that were small type and/or handwritten (these were also very difficult to read from a distance). (Note: This did not appear to cause a problem, however, since nearly all of the approximately 400 vu-graphs were included in the students' notebook in the same order presented.)

Questions were raised and comments made by students in both groups during class time. There were more of each during the vu-graphs presentation at the U. of Md. Many questions or comments in both groups related to correcting minor errors in the equations or the notation being used. (Note: Once vu-graphs have been corrected, this should not be a recurring problem.) There appeared to be differences also in the types of questions asked by the two groups. Early in the week (by Tuesday) participants in the U. of Md. class began to ask questions regarding applications, alternative procedures by other authors, etc. As early as the Sunday introduction and overview session, there were requests for references to use as supplementary reading. Repeated requests for additional references were made early in the week both in and out of class.

Tapes

Audio cassette tapes were made during the Tuesday morning and afternoon sessions of the Kalman Filtering course at both locations. Each tape is labeled and dated. The cassettes are color coded in the upper left for easy identification (green for U.C.L.A., and red for U. of MD). The Sunday evening introduction and overview session was also taped at the University of Maryland (blue color code).

Taping was done from a stationary recorder while the instructors moved to different locations around the front of the room. Sound quality therefore varies and is not uniform throughout.

ADDITIONAL COMMENTS

Students were uncomfortable from the beginning with the resources provided in the vu-graph method. It was, therefore, decided (Ingersoll, LeMay and Lathrop) early in the week to make copies of the notes used in the lecture method at UCLA available to participants. Students were provided with an additional notebook, and notes were distributed one or two sections at a time as they were duplicated for several days. The first and final sections were mailed to them several weeks following the course.

It was not clear to the observer whether the differences observed regarding the questions students asked had to do with the methodology used, the prior knowledge and experience of the participants, the size of the group, and/or physical setting, etc. Hopefully insight into this will be gained from final results of this study.

Although the course was advertised nationally and some people traveled great distances to attend, for the most part participants came from the part of the country nearest to the program they attended. Although Kalman Filtering has been offered many times at UCLA, this is the first time it was offered on the East Coast. It may be that this could account for some of the differences observed in the type of questions and comments. (Dr. Brogan made an interesting comment that over the years at UCLA he has observed a change in the interest of students attending from a theoretical approach to more practical concerns. My unsubstantiated hunch is that the U. of Md. participants had a greater interest in the theoretical aspect. Also, it is interesting to note that the man who asked the most questions and whose interest was obviously very practical came from New Mexico. Hopefully, both instructors will be interviewed for additional insights they can provide.

At both locations two other evaluation forms were obtained from the students. This may have detracted somewhat from the care with which students completed the post-test. These forms might also contain additional information that would provide insights into the similarities or differences of student participants. Copies of the results obtained from Maryland have been forwarded under separate cover with the notebooks and tests to UCLA. *

One of the most knowledgeable students in the class at UCLA (as judged by the observer from the sophisticated questions he asked throughout the week) expressed concern to the observer following completion of the post-test that students were asked to write a number of complex and elaborate equations from memory. He had not committed them to memory, preferring to use his notes for reference when he needed this information for his work.

One probability theory concept of fundamental importance in this course involved the expectation operator, "E." Its meaning became a repeated and humorous question during the class at UCLA. One day Dr. LeMay found a small paper with the following anonymous poem placed on his lecturn:

When explaining what Kalman's "gig" be,
LeMay turned and he asked, "Do you dig me?"
The entire class
Answered en masse
"What in the hell is 'big E'?"

The observer timed topics and took extensive notes during both presentations. If this or any additional information or comments would be helpful, please feel free to contact:

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901 Dreams Landing Way
Annapolis, MD 21401
(301) 266-0966

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* Also, at the U. of Md. students did not spend as much time completing the posttest. A number of them worked in the immediate area and may have gone back to work. (One woman told me this was her intention. I noticed when she turned in her post-test that she did not complete it.)

KALMAN FILTERING COURSE GOALS

- Provide Elements of Disciplines Required for Understanding of Kalman Filtering
- Present Derivation of the Kalman Filter and the Extended Kalman Filter
- Delineate Application Steps Using Both Simple and Complex Examples
- Identify Techniques for Solving the Most Significant Problems Occurring in Kalman Filtering Applications (Example: Filter Divergence)

KALMAN FILTERING COURSE CONTENTS

Elements of Probability Theory Including Order Statistics

Elements of Random Process Theory

- Markov Models and Properties
- White Noise and Colored Noise
- Shaping Filters

Elements of Estimation Theory

- Equivalence of Estimators
- Gaussian/Linear Filter Equivalence

Derivation of Kalman Filter and Simple Examples

Derivation of Extended Kalman Filter and Simple Examples

Kalman Filtering Applications

Computational Considerations and Alternate Formulations

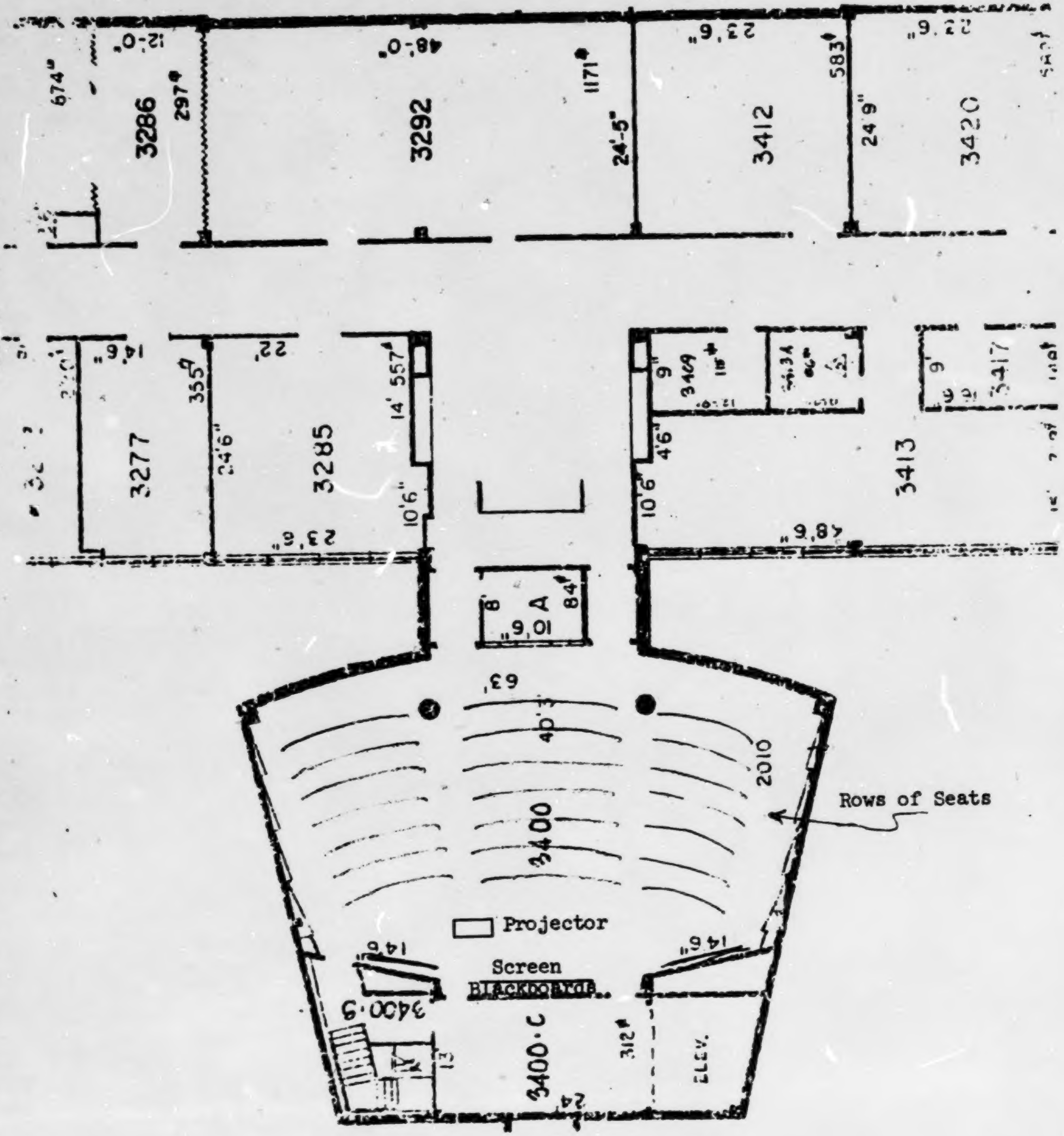
Adaptive Estimation

Excluded:
- Nonlinear Filtering
- Suboptimal Filtering

Kalman Filter: An Algorithm (Data Processing Scheme) to Compute an Optimal Estimate of the State of a System, Given Measurements, Initial Conditions, and Statistical Parameters

KALMAN FILTERING

Definition: An Algorithm for Computing an Optimal Estimate of the State of a System Using Initial Estimate and Noisy Measurements.


3286
3292
3412
3420
3277
3285
3413
A
3400
3400·C
3400·B
2010
ELEV.
Projector
Screen
Blackboards
Rows of Seats

UCLA CLASSROOM LAYOUT

CONFERENCE ROOM: 0105

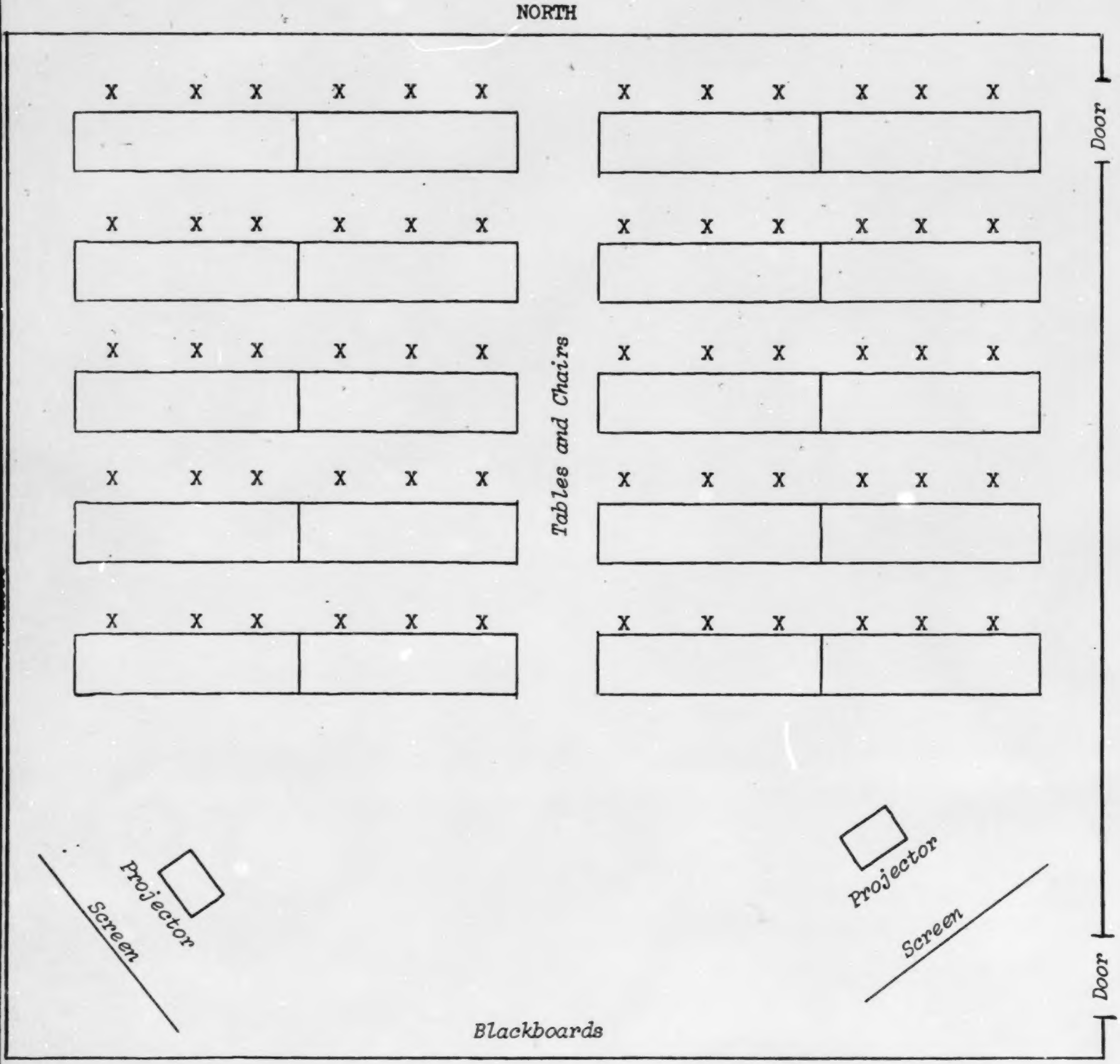
PROGRAM: Kalman Filtering

DATES: 9/9-14/79

ARRANGED BY:

34' x 39' - Capacities: Theater - 146; Schoolroom - 96, "0" - 48

University of Maryland
Classroom Layout


NORTH
Door
Tables and Chairs
Projector
Screen
Projector
Screen
Door
Blackboards

220

APPENDIX 5

OBSERVATIONS OF COURSE INSTRUCTORS

Conversation with Dr. Richard Hamming, June 30, 1980

"It is not surprising to me that the study has shown no significant difference between blackboard and view graph modes of delivery. Nor is it surprising that the blackboard students of mine came off better than the view graph students. While it is true that the blackboard students were to a greater extent employed in research, and this would account for their better pretest as well as posttest scores. I believe also that the two teaching modes have different realms of greatest effectiveness. In a course where factual material is presented, I believe the view graph mode would be the most effective. Where the objective of the course is to teach the student to think, however, I believe the blackboard and lecture would be superior. It seems to me that your results have confirmed this, for the character of the Digital Filters course is exactly that, to teach the student to think in these terms."

Conversation with Dr. Joseph LeMay, June 30, 1980

"I can easily understand that the students would prefer view graphs, because if they are well done, the communication and instruction is apparently enhanced. I say apparent because it is terribly easy for the student to look at a view graph, think he has it all committed to understanding, and then find later that the whole thing went right over his head. I try to keep two things in mind when preparing or using visual projections for a short course or seminar, (1) that the visual be fully and comfortably visible to every person in the room. This means that colors (if used) must be pretested for sharpness in a partially lighted room, that all letters and symbols on the transparency be above a certain critical size, and that every seat in the house have a good view of the screen, and (2) that it is all too easy for the instructor to cover view graph materials at too fast a rate for student reception. In the blackboard mode, the instructor is saved from this by the physical limitation of writing on the board. To guard against too high "feed rates" in using view graphs, I make it a firm policy to go over each transparency twice with the class, using somewhat different language the second time, but covering each point twice."